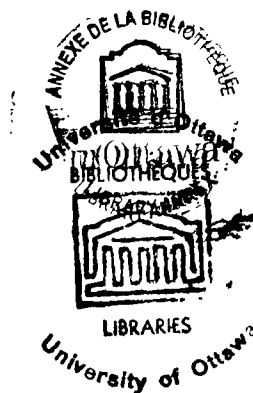


A DEFINITIONAL STUDY OF J. S. BRUNER'S EXPLANATION
OF A FUNDAMENTAL INTERNAL STRUCTURE OF KNOWLEDGE
IN THE PROCESS OF EDUCATION

by Roland Piché

Thesis presented to the Faculty
of Education of the University of
Ottawa as partial fulfillment of
the requirements for the degree
of Doctor of Philosophy



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CURRICULUM STUDIORUM

Roland E. Piché was born October 3, 1927, in Gravelbourg, Saskatchewan. He received the Bachelor of Arts degree from the University of Ottawa, Ottawa, in 1946 and the Licentiate in Philosophy degree from the same University in 1949.

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INTRODUCTION

In the 1950's a movement in curriculum design emerged spirited by scholars and scientists concerned with the improvement of scientific education. Their main tenet was that the organization of the curriculum should be based on the structure of a discipline. This principle was the guiding light for several new science and mathematics curricula which were created at that time.

There came a time when the main active forces behind this curriculum movement became convinced that a general appraisal of "progress in, and concern for creating curricula and ways of teaching science was in order".¹ The National Academy of Sciences called a meeting under the chairmanship of Jerome S. Bruner, a psychologist from Harvard University, "to examine the fundamental processes involved in imparting to young students a sense of the substance and method of science".² The scientists who had been engaged in constructing curricula, some psychologists and historians were invited to a ten-day conference known as the Woods Hole Conference to discuss these matters.

1 Jerome S. Bruner, The Process of Education, Cambridge, Harvard University Press, 1960, p. vii.

2 Ibid., p. vii.

As chairman, Bruner prepared the report of the conference and published it under the title of The Process of Education; it is sometimes referred to as the Woods Hole Conference Report.

The Woods Hole Conference Report or The Process of Education became a best seller. No doubt Bruner's style of writing contributed to its popularity but it would not be amiss to say that the sense of urgency he conveyed and the enthusiasm he generated were also factors that struck a responsive chord.

Many of the educators who attempted to project or to apply his principles met with some serious difficulties with some concepts, perhaps suspected but not envisaged, in the enthusiasm of cursorily reading The Process of Education; such was the concept of the structure of a discipline.

The original and later reactions of the author of this research to the concept of the structure of a discipline followed the pattern--enthusiasm followed by frustration. A more sustained and thorough effort seemed worthwhile to come to grips with Bruner's concept of the structure of a discipline. After many gropings it became evident that Bruner had very little to say about the structure of a discipline 'in se' but much to say about the development of internal structures of knowledge in relation to the structure of a discipline or subject. As a result the focus of investigation changed from

a consideration of Bruner's concept of a structure of a discipline to a consideration of Bruner's concept of a fundamental internal structure of knowledge as found in The Process of Education.

Part I of the report of the investigation deals with the research problem and the methodology used. It comprises three chapters: Chapter I gives the background to the problem; Chapter II states the problem and explains the conceptual schema which guided the study; Chapter III presents the theoretical and practical rationale of the methodology.

Part II constitutes the main body of the report. Various aspects of a fundamental internal structure of knowledge are analyzed based on what Bruner communicated in The Process of Education. Part II comprises five chapters each dealing with a particular aspect of a fundamental internal structure of knowledge derived from the conceptual schema. Chapters IV to IX analyze the nature, the characteristics, the factors and the purposes of a fundamental internal structure of knowledge.

Part III consists of two chapters. In Chapter X, the results of the analysis are translated and integrated into a classification schema of definitions; this constitutes Bruner's explanation of a fundamental internal structure of knowledge as translated and integrated. In Chapter XI, this explanation is compared from the point of view of clarity to

Bruner's explanation as presented in The Process of Education.

Finally, the contents of the report are summarized and suggestions for further research are given.

PART I

THE RESEARCH PROBLEM AND THE METHODOLOGY

CHAPTER I

BACKGROUND TO THE PROBLEM

Historically, new concepts and the words used to express them dominate disciplines and emerge as catalysts and points of departure for innovations, evolutions and research in specific disciplines.

In 1960, Jerome S. Bruner published his epoch-making best-seller The Process of Education.¹ He introduced the word 'structure' which soon acquired widespread usage and popularity in educational thinking, innovation and research. It became the central concept in American Curriculum studies and remains a key concept in most curriculum approaches.

This chapter outlines the causes of curriculum reform in the United States in the 1950's and the resulting emergence of a new terminology, isolates the obscure meaning of one of those terms--structure, and reports some of the criticisms levelled against Bruner's lack of a definition of structure. This survey provides the background for the following chapters in which the research problem is stated and the methodological approach described.

¹ Jerome S. Bruner, The Process of Education, Cambridge, Harvard University Press, 1960, xvi-97 p.

1. Curriculum Reform in the United States in the 1950's

In the 1950's a pattern of curriculum reform emerged in the United States which eventually altered the bases of curriculum content and design.

The spread of progressivism² and the growth of scientific knowledge and technological know-how³ particularly after the war, had created an ever-widening gap between the university and the schools. In their concern for the development of social processes in the schools, American educators had, to some extent, neglected the research activities of the scholars; the latter, motivated and enthused by the phenomenal developments in their field of endeavour, had abandoned the educators and failed to disseminate and to integrate their new knowledge in a manner understandable to educators and perforce to students.⁴

Because of this, scientific scholars were appalled by the poor preparation of their undergraduate students.

2 Lawrence A. Cremin, The Transformation of the School, New York, Vintage Books, Random House, 1961, 387 p.

3 Richard Miller, Education in a Changing Society, (National Education Project on Instruction), Washington, NEA, 1963, 166 p.

4 National Science Foundation (Staff, Division of Scientific Personnel and Education), "The Role of National Science Foundation in the Course Content Improvement in Secondary Schools", The School Review, Vol. 70, No. 1, issue of Spring 1962, p. 3.

However,

... After a period of merely asking what was wrong and excoriating the schools, scientists concluded that they themselves had a responsibility to help the schools in a substantial way. They adopted the view that those who know modern developments best, who know the intricacies and structure of their subjects, should help design appropriate courses and materials that reflect contemporary knowledge and points of view.⁵

Thus began in the 1950's, intensive and extensive curriculum reform spear-headed mainly by the National Science Foundation.⁶

2. New Terminology

With this reform came a new terminology. Terms such as "cybernetic design",⁷ "module",⁸ "resources"⁹, "taxonomy",¹⁰

5 Ibid., p. 5.

6 Hulda Grobman, Developmental Curriculum Projects: Decision Points and Processes, Itasca, Illinois, F. E. Peacock Publishers, 1970, p. 3.

7 Karl U. Smith and Margaret Folts Smith, Cybernetic Principles of Learning and Educational Design, New York, Holt Rinehart and Winston, 1966, 529 p.

8 J. Lloyd Trump, "Flexible Scheduling--Fad or Fundamental?", Phi Delta Kappan, Vol. 44, No. 8, issue of May 1963, p. 367-371.

9 J. Lloyd Trump and Dorsley Baynham, Guide to Better Schools: Focus of Change, Chicago, Rand McNally, 1961; 147 p.

10 Benjamin S. Bloom, ed., Taxonomy of Educational Objectives, Handbook I: Cognitive Domain, New York, Longmans, Green and Co., 1956, 209 p.

"programmed instruction",¹¹ "teaching machines",¹² "systems designs",¹³ "retrieval systems",¹⁴ to name just a few, borrowed from science and technology, worked their way into, and became quite firmly entrenched in the official language of education.

Amongst these new terms, one key phrase was prominent: 'structure of a discipline', a term which received continent-wide dissemination in the 1960's, following the publication of Bruner's The Process of Education. Kliebaard states that:

In just a few years, structure of the disciplines has become a kind of rallying cry occupying about the same position that the whole child and education for democratic living have held in other times.¹⁵

Many curriculum specialists were and are using and referring to the terms 'structure' and 'discipline' in

11 A. A. Lumsdaine and Robert Glaser, Eds., Teaching Machines and Programmed Learning: A Source Book, Washington, Department of Audiovisual Instruction, NEA, 1960, xii-724 p.

12 Ibid.

13 Donald Ely, "Facts and Fallacies about New Media in Education", in Alfred de Grazia and David A. Sohn, Eds., Revolution in Teaching: New Theory, Technology, and Curricula, New York, Bantam Books, 1964, p. 132-140.

14 Henry J. Dubester, "Libraries and Information Retrieval", The American Behavioural Scientist, Vol. 6, No. 3, issue of November 1962, in Revolution in Teaching: New Theory, Technology, and Curricula, New York, Bantam Books, 1964, p. 132-140.

15 Herbert M. Kliebaard, "Structure of the Disciplines as an Educational Slogan", Teachers College Record, Vol. 66, No. 7, issue of April 1965, p. 598.

theoretical and applied curriculum studies. Yet, the referents in the phrase 'structure of a discipline' are difficult to establish and specify. In Deciding What to Teach, a supporting volume of the official report School for the Sixties¹⁶ for the National Committee of the NEA Project on instruction, Fraser states:

In current discussions such expressions as the structure of the discipline [...] are often used without clear definition. These terms carry different meanings for different persons [...] A first task, therefore, is to clarify the meanings of such terms and the concepts they represent.¹⁷

Caswell adds:

... one wonders whether the concept of designing the curriculum of elementary and secondary education on the basis of the structure of knowledge is not about as slippery as some of the other concepts that have been employed in the past.¹⁸

Kliebaard reinforces the same thought:

... As with other slogans, one of the difficulties with the structure of the discipline is that there is some confusion as to what it means.¹⁹

16 Schools for the Sixties, A Report of the NEA Project on Instruction, New York, McGraw-Hill, 1963, 146 p.

17 Dorothy M. Fraser, Chairman, Deciding What to Teach, Report of the Project on Instruction, Washington, NEA, 1963, p. 20.

18 Hollis L. Caswell, "Difficulty in Defining the Structure of the Curriculum", in A. Harry Passow, Ed., Curriculum Crossroads, New York, Teachers College Press, 1962, p. 108.

19 Herbert M. Kliebaard, Op. Cit., p. 598.

When referring to the difficulties that the social sciences have had of "digesting Brunerism", Brown says: "In these disciplines, [...] scholars have had a more difficult time agreeing on what the structure of a discipline is".²⁰

3. An Obscure Common Term: Structure

Inlow reviewed some of the literature on structure and discipline and came to the conclusion that theorists do not even agree on the meaning of the term "structure".

... Basic to the entire issue, of course, is the meaning that the respective theorists ascribe to the word structure. In searching for an answer, I often felt that the theorists, like the fabled six blind men of Indostan were reacting to different parts of the academic elephant.²¹

The same conclusion was reached by Lammell:

... Further amplification and clarification is needed on several of the basic issues connected with the teaching of subjects derived from the disciplines. Structure or structures, learning through discovery, and processes of inquiry have been the focal points of curriculum innovation. But the delineation of the specifics is by no means complete or adequate. A prime difficulty lies in the complexity of each of the ideas.²²

20 Richard H. Brown, "History and the New Social Studies", Saturday Review, issue of October, 1966, p. 80.

21 Gail M. Inlow, The Emergent in Curriculum, New York, Wiley, 1966, p. 15.

22 Rose Lammell, "General vs. Special Methods in Teaching the Disciplines", Theory into Practice, Vol. 5, No. 2, issue of April, 1966, p. 90.

In a book published in August 1966, six years after Bruner's work, Fenton states: "As yet no consensus about the meaning of the term 'structure' has developed".²³

After reporting on some of the difficulties experienced by scholars in deciding what is to be taught, Clinchy writes: "It thus becomes clear that 'structure' is often a slippery term".²⁴

Ford and Pugno summarize the opinions concerning the elusiveness of the 'structure' concept in the following statement: "... It could well be that the concept 'structure of knowledge' is an educational expression in search of definition".²⁵

Scholars recognize Bruner, through his writings, as an important source of dissemination of the concept of structure. Referring contextually to Bruner's concept of structure, Fenton comments:

23 Edwin Fenton, Teaching the New Social Studies in Secondary Schools: An Inductive Approach, New York, Rinehart and Winston, 1966, p. vi.

24 Evans Clinchy, "The New Curricula", in Donald Gross and Judith Murphy, Eds., The Revolution in the School, New York, Harcourt, Brace & World, 1964, p. 224.

25 G. W. Ford and Lawrence Pugno, The Structure of Knowledge and the Curriculum, Chicago, Rand McNally, 1964, p. 1.

... The literature about curriculum development is filled with reference to Brunerian concepts, and speeches at meetings of professional associations abound with references to his work.²⁶

4. Need for Clarification of the Concept of Structure

It is quite evident that Bruner's concept of structure does not have the same meaning for the scholars themselves. Miel criticized McLuhan's understanding of Bruner's concept of structure in the following terms:

McLuhan gives credit to Bruner for "an account of the structural approach" as one involving depth awareness of a simultaneous field of relations. It is clear, however, that Bruner is referring to the structure of a subject by more complex lineal arrangements. If so, there is a real difference between his view of structure and those of McLuhan.²⁷

Reviewers of The Process of Education have deplored the fact that Bruner has never defined structure. Thus, Eason and Heimler state that "nowhere in the book is the term adequately explicated".²⁸ Stokes writes also: "At no point in the report of the Woods Hole Conference is a specific definition

26 Fenton, Op. Cit., p. 81.

27 Alice Miel, "Knowledge and the Curriculum", in Alexander Frazier, Ed., New Insights and the Curriculum, 1963 Yearbook of the Association for Supervision and Curriculum Development, NEA, 1963, p. 79.

28 Elmer Eason and Charles H. Heimler, "A Keystone Concept with a Resolute Ring", in Phi Delta Kappa, Vol. 43, No. 1, issue of October 1961, p. 40.

of structure given".²⁹

Newmann acknowledges the difficulty of understanding Bruner's unstructured 'concept of structure': "Problems of clarity and definition arise".³⁰

Eastwood examined the processes by which a slogan is introduced into the language and rendered acceptable by educators. He cited and analyzed, as an example, "J. S. Bruner's introduction of the term 'structure' into the context of education".³¹ He continues: "Bruner's general thesis is not questioned--concern is essentially with its presentation under slogan labels".³² Eastwood's analytical study lays bare the ambiguity of the term "structure" as presented in the Woods Hole Conference Report.

5. Summary

Thus, in curriculum studies, the following facts emerge: in the 1960's many curriculum specialists made the

29 William Woods Stokes, An Analysis and Evaluation of Current Efforts to Improve the Curriculum by Emphasis on Disciplinary Structure and Learning by Discovery, Florida, Gainesville, (Photocopy), 1963, p. 16.

30 Fred M. Newmann, "The Analysis of Public Controversy: New Focus on Social Studies", in School Review, Vol. 73, No. 4, issue of Winter 1965, p. 412.

31 Gordon R. Eastwood, "Observation on Slogan System", in Canadian Education and Research Digest, Vol. 4, No. 3, issue of September 1964, p. 208.

32 Ibid., p. 209.

concept of structure central to many new programmes; though much of the impetus for the 'structure' approach was due to Bruner, there is still much confusion as to Bruner's concept of structure; criticisms of Bruner's concept of structure arose on the occasion and as a result of his use of the expressions "structure of subject matter", "structure of Disciplines" as a curriculum principle in his more widely known publication The Process of Education.

Is Bruner's explanation of the concept of structure as presented in The Process of Education as confusing and ill-defined as the critics say? Would systematic analysis of The Process of Education yield an integrated explanation of Bruner's concept of structure which would be clearer than his explanation as presented? The purpose of this research is to find a partial answer to these questions.

The following chapter delimits the object of this research and describes a conceptual framework which will permit an analysis of Bruner's The Process of Education in terms of certain imposed limits.

CHAPTER II

STATEMENT OF THE PROBLEM AND SOLUTION CRITERION.

As indicated in the preceding chapter, Bruner's critics accuse him of not having defined 'structure' in his proposal that the structure of a discipline be made a central principle in curriculum design. The implication is clear: it is futile to discuss Bruner's proposal without a clear definition of his concept of structure.

1. Statement of the Problem

This paper does not purport, however, to seek a definition of Bruner's concept of structure in general but to ferret out from an analysis of The Process of Education, an integrated explanation of Bruner's concept of a structure of knowledge. But even this statement must be made more precise. Bruner's whole argument on the importance of structure in curriculum design is based on the assumption that there is a strong relationship between a fully developed psychological structure of knowledge and the fundamental structure of a discipline or of a subject matter--witness the organization of the chapters in The Process of Education: the first chapter deals with the importance of structure but in the following chapters Bruner purports to describe the psychological processes and facilitators for developing

"internal structures",¹

The psychological orientation of The Process of Education imposes the study of a fundamental internal structure of knowledge as a preliminary step to a future study of Bruner's concept of structure 'in se' or of his concept of the fundamental structure of a discipline. The concern of this research therefore is with fundamental internal structures of knowledge not with the structure of a discipline or the structure of a subject matter as such.

One is attempting to find an answer to the following questions: What integrated explanation of Bruner's concept of a fundamental internal structure of knowledge results from an analysis of Bruner's explanation as presented in The Process of Education? Is this integrated explanation clearer than Bruner's explanation as presented?

2. The Solution Criterion

To analyze and integrate Bruner's explanation of a structure of knowledge, it is necessary to have a clear notion of what constitutes an explanation. According to Bochenski the term 'explanation' is ambiguous, for

¹ Jerome S. Bruner, The Process of Education, Cambridge, Harvard University Press, 1960, p. 37.

... Sometimes an explanation may be concerned with the meaning of a sign. This, however, is the province of definition, [...] An explanation may [...] also be concerned with a statement--and thus with an objective proposition--the meaning of which is already known [...] It consists always of deriving the statement concerned from another statement. In general, therefore, 'explain' in this sense means nothing other than constructing an axiomatic system, in which the statement to be explained is derived...²

In this research, the concern is with a definitional explanation. It is assumed that Bruner gives an implicit definitional explanation of 'a structure of knowledge' in The Process of Education; this definition has to be made more explicit.

A schema of the kinds of definitions sufficiently comprehensive to encompass the derived definitions is necessary.

Concerning definition and the kinds of definition, Bochenski states:

... The term 'definition' is applicable to almost any answer to the question 'what is x'? where 'x' stands for any expression whose meaning remains constant. It is obvious that these answers can be of such different types that the term 'definition' itself is ambiguous. The earliest distinction to be drawn, which is due to Aristotle and is still current today, is between real and nominal definition; real definition says what some thing is, nominal refers not to a thing but to a sign. In the nineteenth century various philosophers (including Wundt) tried to reduce all definitions to nominal definitions; but contemporary methodology distinguishes between the two kinds.³

2 J. M. Bochenski, The Methods of Contemporary Thought, New York, Harper & Row, 1968, p. 93.

3 Ibid., p. 81.

The distinction between nominal and real definitions is retained in this research and the various types of nominal and real definitions as found in Patry's classification schema of definitions⁴ will be used; they are reviewed in the following pages.⁵ This is followed by assumptive statements concerning the classification schema.

A. Patry's Classification Schema of Definitions

A definition marks the boundaries of a concept. There are several more or less clear definitions and each type of definition marks the boundaries of a concept in a different way.

Let us recall first the two general groups of definitions: the nominal and the real definitions. A nominal definition explains the word though it could indirectly refer to the thing signified by the word. There are three types of nominal definitions: 1) etymological, which explains the origin of the word, e.g. 'appeal' comes from the latin word 'appellare' and means 'to approach', 'to invoke'; 2) common, which approximates the dictionary meaning of the word, e.g.

4 Marcel Patry, Réflexions sur les lois de l'intelligence: Etude de logique, Montreal, Fides, 1965, p. 75.

5 The explanations given by Celestine N. Bittle in The Science of Correct Thinking (Logic), Milwaukee, Bruce, 1950, p. 75-87, passim, have been incorporated into Patry's classification schema.

'appeal' means 'a call for aid', 3) synonymical, which explains a word by means of another word whose meaning is nearly the same e.g. 'appeal' and 'plea' are synonymous.

A real definition, on the other hand, explains what a thing is. A perfect real definition would be one which briefly but fully explains the nature of a thing. Such a definition is not reached completely in most cases.

A real definition may be intrinsic or extrinsic. An intrinsic definition attributes a quality found in the thing itself. It refers either to the essence of a thing or to its accidents; in the first case, the definition is said to be an essential definition; in the second case, a descriptive definition. Essential definitions are said to be physical if they give the real physical parts of a thing (water consists of H_2O) or logical if they indicate the essence or nature of a thing by its proximate genus and specific difference (a plant is a living non-sentient being). It is not sufficient in a logical definition to state the intermediate or remote genus--the proximate genus must be stated; nor is it sufficient to state a difference--the specific difference must be stated. A descriptive definition explains what a thing is in itself by enumerating positive but non-essential elements of its nature either by one or more of its properties (man is capable of knowing) or by a set of characteristics not connected with its essence

(Peter Smith: age, 42 years; height, 6 feet; weight, 175 pounds; etc.).

An extrinsic definition indicates the exterior causes of the thing, of which there are two--the agent(s) and the purposes. . To state that a painting is something produced by an artist is to indicate its agent; to state that a watch is something to indicate the hours of the day is to indicate its purpose.

The whole classification may be represented as in the schema on the following page.

B. Assumptions Concerning the Classification Schema

It is assumed that the classification schema presented above is sufficiently comprehensive to encompass that which can be predicated and understood of something--at least in its general configuration.

This assumption is based on the relationships between the types of definitions within the schema and the different ways of predicating something about the entity on which one is focussing, not on a comparison with other classifications which, for all practical purposes, could be just as valid.

It is assumed further that there is a logical relationship between the classification schema and Aristotle's theories of categorization and causation.

Table I.- Classification Schema of Definitions.^a

Nominal		-----	{	Etymological
				Common
				Synonymical
Real	{	Intrinsic	{	Essential
				{ Physical
				Logical
			{	Descriptive
				{ Set of accidents
	{	Extrinsic (Genetic)	{	Agent
				Purpose

^a Translated from Marcel Patry, Réflexions sur les lois de l'intelligence, Montréal, Fides, p. 75.

First, what can be said about a structure of knowledge, whether to explain its nature or its relationships to other entities falls into a few categories which Aristotle and his followers list as follows: substance, quantity, quality, relation, action, passion, place, time, posture, habit.

The classification schema covers what can be predicated of the nature of a thing as a constituted real entity with its essential components (logical definition) and accidental attributes (descriptive definitions). Thus it allows for predication as to the type of being to which the constituted entity belongs and as to the type of beings which are related to it.

Secondly, the classification schema covers what can be predicated of the existential principles--as formulated in Aristotle's theory of causation--on which depends a constituted entity. Thus, it allows for predications concerning the constitutive elements of an entity i.e. its indeterminate and determinate components (the physical definitions) and for predications concerning its extrinsic factors (extrinsic definitions).

The classification of definitions provides a convenient framework into which propositions derived from an analysis of Bruner's explanation of a structure of knowledge as presented can be translated and integrated.

In this research, an Aristotelian conceptual framework based on Patry's classification schema of definitions is used as a solution criterion to the problem posed. As a first step, a workable unit of linguistic data has to be found; secondly, the units of linguistic data have to be analyzed with a view to teasing out propositions which encapsule Bruner's intended meaning; thirdly, the propositions themselves have to be translated into the classification schema of definitions.

These requirements imply a methodological rationale to which the next chapter attends.

CHAPTER III

THE RATIONALE OF THE METHODOLOGY

On the assumption that the classification schema of the definitions presented in Chapter II is commensurate with the modes of predicating something about an internal structure of knowledge, one can now proceed with the ways and means of transforming Bruner's explanation of it as presented into a number of propositions and of translating them into the language of the schema.

The basic data used in this research are linguistic. One assumes that through language the author of a communication intends to give an explanation of a particular entity though that explanation may be hidden, vague and incomplete. Through an analysis of the linguistic data the reader attempts to recapture the meaning an author wishes to convey about that particular entity.

But the analysis of linguistic data is based on one's position regarding the nature of the relationships between language and reality and between language and thought. The first section of this chapter therefore states a theoretical position vis-à-vis the relationships between language and reality and between language and thought and the consequences therefrom. The second section discusses the procedures and techniques used: 1) to identify, group and interpret the

data; 2) to translate the findings and integrate them into the classification schema; 3) to appraise Bruner's explanations as presented and as translated and integrated. Supplementary techniques concerning the order of presentation are also presented.

1. The Nature of the Relationships between Language and Reality and between Language and Thought and its Implications for the Study of an Author's Communication

The nature of these relationships as assumed by the Aristotelian and scholastic philosophers constitutes the basis for the development of procedures and techniques a reader could use to help him recapture the meaning an author has of a particular reality.

As stated briefly by Lyons, Aristotelian and scholastic philosophers assumed that:

... the different modes of predication represented differences in the objective world, the different modes of being [...] that the physical world consists of things ('substances') which have certain properties ('accidents'), initiate or undergo certain processes, stand in a certain relationship to one another, or have a certain extension or location in space or time [...] that the structure of language reflected the structure of the world: that words signified things according to their mode of 'being', as 'substances' or 'accidents'...¹

¹ John Lyons, Introduction to Theoretical Linguistics, London, Cambridge University Press, 1968, p. 271.

In the technical language of the school, these modes were known as the modes of being, the modes of understanding and the modes of signifying.²

The next few pages examine the relationships between language and reality, between thought and language and their implications for the study of an author's communication.

A. Language and Reality

Charlesworth has defined language as "a system of instrumental signs which have a material or physical existence of their own apart from their signifying function".³ When an author wishes to communicate something, it is the signifying function to which he and the reader must attend. Language as an instrument of meaning is used to signify or mean something beyond itself.⁴ It follows that for language to signify something, certain conditions must be met.

What are the "necessary conditions [...] which govern the meaningful use of language"?⁵ According to Charlesworth,⁶

2 Lucien Martinelli, Thomas d'Aquin et l'analyse linguistique, Montréal, Institut d'Etudes Médiévales, 1963, p. 57.

3 Maxwell John Charlesworth, Philosophy and Linguistic Analysis, Pittsburgh, Duquesne University Press, 1961 (c 1959), p. 216.

4 Ibid., p. 216.

5 Ibid., p. 217.

6 Ibid., p. 217-218.

they can only be determined by reference to what is meant, i.e. to reality itself. And reality is made up of substances and accidents of substances. Therefore, when one uses language meaningfully, the terms used signify the modes of being. In fact this is what is done when terms which have "a naming or referring function (subjects), and others which have [...] an 'applicative' function (predicates) [...] are used to apply something to what the logical subject names or refers to".⁷

And Charlesworth adds:

... these two formulations--the one in terms of substances and properties, which may be called the ontological formulation; and the other, in terms of subjects and predicates, which may be called the linguistic formulation--are strictly equivalent.⁸

Lonergan, though more cautious, is more specific:

"... Grammar almost gives us Aristotle's categories of substance, quantity, quality, relation, action, passion, place, time, posture, habit, ..."⁹

Thus, to use language meaningfully, it is not sufficient to be aware of the senses of words and of the ways of communicating; one must also be aware that what makes the communication possible is its reference to what is meant.

7 Ibid., p. 218.

8 Ibid., p. 218.

9 Bernard J. F. Lonergan, Method in Theology, New York, Herder and Herder, 1972, p. 71.

The student of semantics would find it worthwhile to heed Martinelli's advice stated thusly:

... l'étudiant de la sémantique ou de l'analyse philosophique s'intéresse au sens des mots, à la façon de le communiquer: pourquoi sa curiosité ne porterait-elle pas sur les conditions ontologiques qui rendent cette communication possible?¹⁰

In a communication therefore, the author uses language as an instrument of meaning, i.e. to refer 'after the fact' to what is meant; the reader to capture the meaning intended looks beyond the language of the author to reality itself. The position that the structure of language reflects the structure of the world, allows the reader to analyze and use the linguistic formulations to reach reality itself.

B. Language and Thought

Language is an instrument of meaning i.e. an instrument to signify something beyond itself (see p. 22). But it is the intellect which uses language to express the reality which it understands or presumably understands. Language then is also an expression of thought. It has a double function: it is used to signify things and it is also used to express one's understanding of the things themselves.

The second function is examined in the following pages.

¹⁰ Martinelli, Op. Cit., p. 58.

First, when man abstracts an idea of something, he can express it by means of words. A word which expresses an idea is a term. The term signifies immediately the idea and mediately reality itself but principally it signifies the reality and not the idea. Therefore when an author uses words, he intends to convey to the reader immediately the idea and mediately but principally information about reality itself.¹¹

Secondly, man can compare ideas, recognize their agreement or disagreement with each other and mentally pronounce their compatibility or incompatibility, their identity or unidentity. This mental pronouncement or judgment can be expanded in language in the form of a sentence. A sentence which expresses a judgment is a proposition. A proposition signifies immediately the judgment and mediately a representation of things as they are in themselves, independent of the mind. And Bittle adds:

... When, therefore, the mind compares two ideas with each other and pronounces an agreement or disagreement between them, it actually compares two things with each other and judges about their agreement or disagreement among themselves as they are in reality...¹²

There are three elements which enter into the composition of a judgment: two ideas and the mental act of pronouncing

¹¹ Celestine N. Bittle, The Science of Correct Thinking (Logic), Milwaukee, Bruce Publishing, 1950, p. 67.

¹² Ibid., p. 99.

their agreement or disagreement; there are three elements which enter into the construction of a proposition: a subject, a predicate, and a copula; and there are also three elements in a declarative sentence: subject, verb, predicate.

Therefore, when an author constructs a sentence, he intends to convey to the reader immediately a judgment and mediately the agreement or disagreement of things as they are in reality.

Thirdly, man, through certain judgments which are basic and self-evident (what are known as the basic principles), infers from two judgments in which two different terms are related to a common term, a third judgment which relates the two different terms to each other. This inference is expressed in the form of a sequence of sentences. A sequence of sentences which expresses an inference is an argumentation. An argumentation signifies immediately the inference and mediately through the conclusion a representation of things as they are in themselves independent of the mind.

There are three main elements which enter into the composition of an inference: three judgments, two in which two doubtful ideas are compared separately with the known third, one in which the newly discovered relation of identity or non-identity between the formerly doubtful ideas is now

expressed as known and certain.¹³ There are three elements which enter into the construction of an argumentation: the major and minor premises and a conclusion. And there are three related sentences (or a paragraph) by means of which the argumentation is expressed.

Therefore, when an author constructs a sequence of related sentences, he intends to convey to the reader immediately an inference and mediately the agreement or disagreement of things as they are in reality.

The terms an author uses, the propositions he states, the argumentations he makes reflect immediately his ideas, his judgments and his inferences but mediately reality itself. The material elements are the words, the sentences and the collection of sentences. It is therefore incumbent upon the reader to attempt to understand correctly the author's ideas, judgments, and inferences through a correct interpretation of his terms, his propositions, his argumentation as expressed in words, sentences and related sentences and thereby to acquire information about reality itself.

C. Implications

The nature of the relationships between language and reality and between language and thought has implications for the reader of a communication.

¹³ Ibid., p. 175.

First, since the author of a communication uses language to refer to what is meant, the reader must attend to reality through the linguistic formulations of the author.

Second, since the author also uses language to express the results of his mental efforts to understand reality by means of terms, propositions and argumentations, the reader must attend to the ideas, judgments and inferences of the author through the terms, propositions and argumentations expressed by words, sentences and collection of related sentences.

To accomplish these tasks, the reader must be able to identify and interpret the linguistic formulations in terms of what is meant. The next section deals with the procedures to do so.

2. Procedures and Techniques

The following procedures and techniques which take into account the purpose of this research and the implications of the relationships between language and reality and between language and thought have been used in this research: the identification and grouping of texts; the interpretation of texts; the translation and integration of the findings into the classification schema; a supplementary technique concerning the order of presentation. Each one is presented in more detail below.

A. Identification and Grouping of Texts

One must state at the outset, that an author may use a large number of linguistic formulations to communicate the full meaning of a complex pivotal entity, (i.e. one which is of maximum concern to the author), each one referring to some particular aspect of it. It follows that, if the ontological and linguistic formulations are equivalent, the full communication will reflect a network of ontological categories (substances and accidents) of which the complex entity is the pivot (a substance or an accident).

What are the types of linguistic formulations which an author uses to implicitly or explicitly convey meaning about a pivotal entity?

Basically, the author uses language to help the reader to gain insight into the meaning of reality itself.

In the final analysis, the author uses linguistic formulations with a view to pointing to some aspect of the entity to which he is referring. These linguistic formulations which reflect an intent to convey meaning about some aspect of a pivotal entity have been called 'attributors' in this research.

The use of attributors has the advantages of: focusing one's attention on the relevant linguistic formulations and of separating them from the main text; permitting the

reader to hypothesize about the intent of the author without commitment on his part; bringing together similar linguistic formulations. It has the disadvantage of pulling the linguistic formulations out of context; for this reason, the second step--and a most important one--requires one to place the attributors in their proper context before comparing them, to confirm or reject the original hypotheses.

In the descriptions of the types of attributors given below, the hypothesized intent of the author specifies each type. The syntactical arrangements of the linguistic formulations which are suggested are not meant to be exhaustive; there is too much variety in language to cover all instances.

The author may have the intention of inviting the reader to transfer the meaning or part of the meaning of another entity, presumably better known, to a pivotal entity (the one which is of maximum concern to the author). This would be the case when an author uses vocabulary which gives a synonym, the etymology of a word, a non-technical name, the name of another entity which is similar to, yet different from, the pivotal entity (e.g. a throne is like a chair); uses various figures of speech or a negative adverb with another name (e.g. a chair is not a bench), to cut off false meanings. Such attributors have been called 'peripheral attributors'.

The author may have the intention of either placing the pivotal entity within a larger whole or of indicating its

elements. He could, in the first case, use a sentence in which the grammatical subject is the pivotal entity, the verb a copulative verb, the attribute a universal abstract noun, (e.g. water is an inorganic substance); in the second case, he would use a verb such as 'consists of' as in 'water consists of hydrogen and oxygen'. These attributors have been called 'essential attributors'.

The author may have the intention of pointing to the nature of a pivotal entity or to some aspect of it by means of examples. In that case, he would use a narrative--a collection of sentences--introduced by a stated or implied phrase such as 'for instance', 'for example', 'let me illustrate'. Such attributors have been called 'denotative attributors'.

The author may have the intent of indicating the attributes of or contingent factors about the pivotal entity. In that case, he could use a sentence in which the pivotal entity is the grammatical subject, the verb is copulative, the attribute an adjective; (e.g. water is colourless) or one in which the pivotal entity is the grammatical subject, the verb is intransitive (e.g. water flows), or one in which the pivotal entity is grammatical subject, the verb is transitive and the object(s) a noun or nouns (e.g. water freezes at 32° F.) If the passive voice is used, the grammatical subject is not necessarily the pivotal entity; a conversion is then

necessary; for instance, if the pivotal entity is water, the sentence 'the fire was put out with water', can be converted to 'the water put out the fire'. These attributors have been called 'descriptive attributors'.

The author may have the intention of giving the causal factors or processes on which a pivotal entity depends. This could be the case when he uses a sentence in which an entity other than the pivotal entity is the grammatical subject, the verb is a transitive verb or a process verb, and the object the pivotal entity; (e.g. the energies of hydrogen and oxygen produce water); causal prepositional phrases may also be used as part of the sentence (e.g. John was killed with a knife). Such attributors have been called 'agentive attributors'.

The author may have the intention of giving the motivational or purposive factors on which a pivotal entity depends. This could be the case when he uses a complex sentence in which the principal clause expresses the productive action of the agent and the subordinate clause a reason for this action (e.g. John pumped water from the well because he had to extinguish the fire). It could also be the case when he uses a simple sentence containing a prepositional phrase expressing a reason for his action (e.g. John pumped water for his horses). Such attributors have been called purposive attributors.

An author does not necessarily use all types of attributors. However, from a number of attributors, the reader

may logically derive propositions which refer to some aspect of the pivotal entity not specifically mentioned by the author; this is the case in argumentation.

The attributors--peripheral, essential, denotative, descriptive, agentive, purposive--can be used by the reader to identify the texts of a communication.

Once the texts have been identified according to the type of attributors, it is relatively easy to group those which are more representative and direct.

B. Interpretation of Texts

Once aware of what makes a communication possible by means of language, the reader can proceed to an interpretation of texts with the purpose of grasping the meaning which the author wishes to convey, or at least point to that which he does not understand.

From the many linguistic formulations he attempts to grasp the concepts, the judgments and the inferences of the writer. How?

Let us recall that at the first reading of an author's communication one identifies and groups the texts according to the kinds of attributors concerning a pivotal entity. They are not sufficient to grasp its full meaning; at best, they are strong probabilities which must be confirmed or rejected as the reader's understanding progresses.

From the set of attributors, the reader attempts to understand the terminology, the propositions, and the argumentations. For what terms do the words stand? For what propositions do the sentences stand? For what argumentations does the group of related sentences stand? Ultimately, the reader wishes to express his findings in the form of propositions which are free from the context.

But language is an imperfect medium and it is not possible to always convey clearly the information one wishes to convey. Bittle states:

... Language, however, is at best only an imperfect medium of expression, incapable of giving adequate shape to all the subtleties and nuances of meaning involved in the process of thinking. What is a simple act of the mind must be expressed in a number of words, and the result is often far from satisfactory. [...] yet all language in whatever form strives for the selfsame goal--to convey thought and truth from mind to mind. This is the imperfection of language which forces the mind to weave it into intricate textures of words so that at times the truth is almost more hidden than revealed.¹⁴

In point of fact, the reader may give the wrong interpretation to a perfectly good expression, because his store of meanings is not the same as that of the author.

Moreover, the author himself may contribute to misunderstanding if he uses ambiguous and vague terms and sentences. Adler and Van Doren state concerning words: "... one word

¹⁴ Ibid., p. 119.

can be the vehicle for many terms and one term can be expressed by many words".¹⁵

Is the word the author uses, used in a single sense or in a combination of senses? Are the senses related and how? Does the context give any clue? Is the same term represented by two or more words used synonymously? Can the meaning be derived from other meanings one already has?

To determine the supposition of terms, the attributors must therefore be analyzed singly and collectively by placing them into context.

The effect of placing the words or phrases in context is to specify one among the many meanings of the words or phrases.¹⁶

Muchielli states:

... The meaning or meanings are always understood only through the combination of two series of operations: on the one hand, the mobilization of the entities represented by each word or each concept, and, on the other, the understanding of the context or possible contexts.¹⁷

¹⁵ Mortimer J. Adler and Charles Van Doren, How to Read a Book, revised and updated revision, New York, Simon and Schuster, 1972, p. 100.

¹⁶ Roger Muchielli, Introduction to Structural Psychology, translated by Charles Lam Markmann, published by Avon, Funk and Wagnalls, New York, 1970, p. 17.

¹⁷ Ibid., p. 17.

If the meaning can be specified and the author is consistent, it can be stated in declarative propositions which are context-free.

With respect to sentences, here again, one is faced with the same kind of problems one has with words and phrases. There is no one-to-one relationship between sentences and propositions; this is due first to the ambiguity of the words and perforce to a possible shift in the terms the words express; secondly, some sentences are complex and express several propositions.

Yet the reader must discover what the sentences mean. Adler and Van Doren suggest that the dissection of sentences according to the rules of syntax and their placement as in the case of words in the context of other sentences, help to determine the meaning.¹⁸

With respect to argumentations, it is the collection of sentences which must be analyzed to perceive the connection between propositions.¹⁹ One must find the antecedent propositions to a conclusion. Are there other propositions expressed in the forms of sentences which allegedly support the major propositions of an argumentation? Does it point to one or more particular facts as evidence for some

18 Adler and Van Doren, Op. Cit., p. 125.

19 Ibid., p. 120.

generalization? Or does it offer a series of general statements to prove some further generalization? What are the propositions which the author assumes?

The conclusion is of course a proposition which states something about the pivotal entity in the form of a declarative sentence.

Denotative attributors present a particular problem since they represent the extension of an idea rather than its comprehension. Still the author is attempting to convey a particular meaning about the pivotal entity through an illustration. Examples may be used to illustrate any aspect of a pivotal entity.

That is why an example must always be referred, to be properly interpreted, to the meaning of which it is an extension. The reader must be aware of the danger of attending to the wrong aspect. On the other hand, from a good example, he may derive several propositions which are valid in terms of extending the meaning of the entity under study.

C. Translating and Integrating the Findings into the Classification Schema

The logical interpretation of the attributors leads to a number of propositions which express as completely as possible the meanings the author wished to convey about a pivotal entity.

The task now becomes one of translating the propositions--the givens--which express judgments concerning what the pivotal entity really is, into the definitions of the schema which express the ways of understanding something about an entity.

A proposition may be translated into the classification schema of definitions by relating it to the type of questions it answers. As an example, the proposition that 'water consists of hydrogen and oxygen' answers the questions 'What is water made of?' 'What are the substances that enter into the composition of water?' By definition, such questions call for a statement that is known as a physical definition.

Another example: the proposition that 'a painting is produced by an artist' answers the questions 'Who produced the painting?' or 'On whom does the production of a painting depend?' By definition, such questions call for a statement that is known as a causal agentive definition.

A more detailed list of questions is given in Chapter X in which the derived propositions are translated into Patry's classification schema.

Once the propositions have been translated into the classification schema of definitions they are to a large extent integrated. This is due to the nature of the classification schema; the relationships amongst the definitions are

fairly evident and it is only necessary to point to them.

D. Appraisal of the Author's Explanation
Concerning a Pivotal Entity

A final task remains--that of appraising the author's explanation as presented and his explanation as translated and integrated in terms of linguistic and notional clarity. Some of their positive and negative aspects will be evident from an inspection of the classification schema. In addition to this, the confusing and ambiguous terms and statements which have not been made clear and which hampered or prevented understanding are recalled.

3. Supplementary Techniques Concerning the Presentation

The above procedures will be applied to the study of Bruner's explanation of a structure of knowledge as presented in The Process of Education. The attributors will be identified, grouped and analyzed; a number of propositions will be formulated following the analysis of each set of attributors.

While such analysis of parts is necessary, it does not, because of its discreteness and because of one's concern for objectivity, reflect entirely the process of acquiring, cumulating and relating knowledge about a pivotal entity.

To circumvent this defect, the conclusions reached at the end of an analysis of a particular set of attributors

will be, in most cases, compared to the preceding set, discussed and finally synthesized into a list of propositions which reflect the findings about the pivotal entity to that point. This means that the list of derived propositions changes as new findings emerge. The list reflects the process as well as the findings; that is why it is called 'an evolving list of derived propositions'. The final evolving list incorporates and cumulates the findings.

Two concerns preside over the order of presentation: concern for clarity and concern for economy. Clarity and economy command that one search first for propositions about the nature of a pivotal entity before attending to its characteristics, causes, relations, etc. That is why the peripheral and essential attributors will be studied first.

As has been stated, the denotative attributors present a particular difficulty since they may be used by an author to illustrate any aspect of a pivotal entity--its nature, its characteristics, etc. Most denotative attributors are therefore not studied as a set but some of them are studied in reference to the particular aspect the author wishes to emphasize. There are, of course, denotative attributors which refer to the same aspect of the pivotal entity; for reasons of economy, some of these are analyzed as a unit; for example, the set of denotative attributors which refers to the nature of the pivotal entity are studied as a unit.

An analysis of the descriptive attributors follows; the entities found in these attributors are intrinsically related to the pivotal entity. Finally, the attributors which express the extrinsic factors--the agentive and purposive attributors--of the pivotal entity are analyzed.

Following the analysis with its conclusions expressed in the form of sentences in a final list of derived propositions, the translation will be made to the classification schema and integration attempted. Bruner's explanations as presented and as translated and integrated will then be compared and appraised.

Finally, a summary of the report will be presented and areas for further research will be suggested.

PART II

ANALYSIS OF ATTRIBUTORS

CHAPTER IV

THE PERIPHERAL ATTRIBUTORS

This chapter purports to analyze the peripheral attributors which Bruner used to convey some notion of the structure of knowledge. The evolving list of derived propositions, revised at intervals, reflects the results of this analysis.

There are two sets of peripheral attributors--negative and positive. The negative attributors refer to entities which are not an internal structure of knowledge; the positive attributors point to some aspect of an internal structure of knowledge by referring the reader to other entities which are different yet similar to it.

Since Bruner attempts to explain an internal structure in the context of teaching and learning, it is in the context of these two activities that the attributors are studied.

The first section analyses the negative attributors; the second, the positive attributors.

1. Negative Attributors

The following pages report texts¹ which point to Bruner's concern for teaching and learning in which structure of knowledge is emphasized as opposed to teaching and learning in which the acquisition of knowledge of products, facts, techniques, specific skills, devices, recipes, is emphasized.

A. Analysis

a) Structure-Coverage.- Reporting on the work done by the Biological Sciences Curriculum Study (BSSC) group, Bruner states:

The main objective of this work [The Process of Education] has been to present subject matter effectively--that is, with due regard not only for COVERAGE but also for STRUCTURE...²

There is evidence in this text of a distinction to be made between structure and coverage though they are not mutually exclusive. There is indeed conjunctivity in the sense that coverage and structure should be taught.

b) Structure--Facts and Techniques.- Bruner holds that teachers should be committed to the type of learning

¹ Capital letters are used within Bruner's quoted texts to highlight important words and phrases.

² Jerome S. Bruner, The Process of Education, Cambridge, Harvard University Press, 1960, p. 2.

that counts i.e. the learning of structure as distinguished from the learning of facts and techniques. He states:

... The teaching and learning of STRUCTURE, rather than simply the mastery of FACTS AND TECHNIQUES, is at the center of the classic problem of transfer...³

This statement is not a denial of the necessity of the acquisition of facts and techniques; rather, the mere mastery of them is insufficient. He writes:

... knowledge one has acquired without sufficient structure to tie it together is knowledge that is likely to be forgotten. An unconnected set of facts has a pitifully short half-life in memory.⁴

Again, structure, facts, and techniques are not the same type of entities though they are not mutually exclusive.

c) Structure--Specific Topics or Skills.- In a recapitulation of the chapter on the importance of structure in teaching and learning, Bruner states that:

... the curriculum of a subject should be determined by the most fundamental understanding that can be achieved of the underlying PRINCIPLES that give STRUCTURE to the subject. Teaching SPECIFIC TOPICS OR SKILLS without making clear their context in the broader fundamental STRUCTURE of a field of knowledge is uneconomical in several deep senses.⁵

Elsewhere, he states that specific skills are useful in tasks "that are highly similar to those we originally learned" while learning the structure of a subject is useful

3 Ibid., p. 12.

4 Ibid., p. 31.

4 Ibid., p. 31.

because it ensures "continuity of learning" and the "transfer of principles".⁶

Thus, while not denying the usefulness of the two types of learning, he obviously places greater value on learning a structure; it is more economical to learn topics and skills in the larger context of structure.

d) Structure--Devices and Recipes.- In a lengthy discussion of intellectual development and its implications for teaching, Bruner criticizes the type of teaching which attempts to present formal explanations based on a logic foreign to the way of thinking of the child. As a consequence, according to Bruner:

... The child learns not to understand MATHEMATICAL ORDER but rather to apply certain DEVICES OR RECIPES without understanding their significance or connectedness.⁷

It is apparent, therefore, that Bruner distinguishes between a mechanically-based and a structure-based application of devices and recipes.

The analysis of Bruner's texts based on the negative terms shows that the teaching and learning of structure is more than teaching and learning specific skills, facts, techniques, recipes, devices or even coverage of subject matter.

6 Ibid., p. 17-18.

7 Ibid., p. 39.

B. First List of Derived Propositions

While there is no reference in this first series of peripheral attributors to a fundamental structure of knowledge, there is no reason for not assuming that what is said of a structure of knowledge does not apply to a fundamental structure.

The first proposition concerning a fundamental structure of knowledge that can be drawn from a consideration of the type of entities to which it is compared may be stated as follows: a fundamental structure of knowledge is not only the knowledge of facts, of techniques, of specific topic and skills, of devices, of recipes:

- a) knowledge of the above must be understood in the context of structure;
- b) specific topics and skills are uneconomical;
- c) devices and recipes are often applied without understanding their significance or connectedness.

2. Positive Attributors

The positive attributors refer the reader to some aspect of a structure of knowledge that can be derived from different yet related entities.

The author of the communication intends to suggest some notion about the pivotal entity rather than dealing

directly with its nature. These attributors are meant to link the pivotal entity to another entity presumably better known in order to bring out a particular aspect of it.

In The Process of Education, such peripheral attributors comprise the following sets: 'structure-general picture', 'structure-model', 'structure-pattern, theory', 'structure-genotype'. For each attributor (e.g. 'structure-model'), the texts are quoted first, followed by summaries, discussions and conclusions which focus on the notions pertinent to a reformulation of the evolving list of derived propositions.

A. Analysis

As suggested above, the entity that a peripheral-positive attributor represents has some feature(s) which are similar to a structure of knowledge; they may be converted into the form: 'Just as ... so is (does) structure'. These attributors about a structure of knowledge must be transformed into clear propositions about some aspect of structure.

a) Structure--General Picture.- Bruner suggests in the following text that the teaching and learning of structure is central to transfer:

... The teaching and learning of STRUCTURE, rather than simply the mastering of facts and techniques, is at the center of the classic problem of transfer. There are many things that go into learning of this kind, not the least of which are supporting habits and skills that make possible the active use of the materials one has come to understand. If earlier learning is to render later learning easier, it must do so by providing a GENERAL PICTURE in terms of which the relations between things encountered earlier and later are made as clear as possible.⁸

The following statements may be extracted from the above text: the learning of structure implies the learning of supporting habits and skills; habits and skills make possible the active use of the materials one has come to understand; early learning must provide a general picture; a general picture elicits clear relations between things encountered earlier and later.

The obvious inference that Bruner wishes the reader to draw is that structure is like a general picture of something; that just as a picture permits one to recognize the relations between things one encounters now as the same kind of relations one encountered earlier in taking or painting a picture, so does structure in which clear relations between things have been established permit one to recognize the relations between things one encounters now as the same kind of relations between things one encountered earlier.

⁸ Ibid., p. 12.

The idea of relations comes out clearly but the nature of the relationship and the terms of the relation as they apply to structure are not clear.

The only conclusion that can be drawn is that a structure of knowledge, like a general picture, permits one to recognize the relations between things one encounters now as the same kind of relations between things one encountered earlier.

b) Structure--Model.- Still on the question of transfer, Bruner links structure and model. According to Bruner, understanding a fundamental structure:

... is to have learned not only a specific thing but also a MODEL for understanding other things like it that one may encounter.⁹

Or again:

... Having grasped the subtle structure of a sentence, the child very rapidly learns to generate many other sentences based on this MODEL though different in content from the original sentence learned.¹⁰

One derives the following statements from the above texts: understanding structure means to have learned a model for understanding other things like it; the structure of a sentence is a model used as a basis for generating sentences different in content from the original sentence learned.

9 Ibid., p. 25.

10 Ibid., p. 8.

It appears from both statements that just as a model may be used to understand and generate other things, so can structure be used to understand and generate other things.

Thus, one concludes that: a structure of knowledge, like a model, once constructed, is instrumental in understanding other things or in generating other things from it.

c) Structure--Pattern, Theory.- In his study of the general claims that can be made for teaching the fundamental structure, Bruner states:

... Perhaps the most basic thing that can be said about human memory, after a century of intensive research, is that unless detail is placed into a STRUCTURED PATTERN, it is rapidly forgotten...¹¹

And in the same paragraph he adds as if elaborating on his previous statement:

... A good THEORY is the vehicle not only for understanding a phenomenon now but also for remembering it tomorrow.¹²

The transformation of the texts yields the following short statements: details placed in a structural pattern are remembered; a phenomenon may be understood and remembered by means of a theory.

The use of the word 'pattern' suggests regularity, sameness; the word 'structured' used in conjunction with it

¹¹ Ibid., p. 24.

¹² Ibid., p. 25.

implies that Bruner is talking about a particular type of pattern. The emphasis is therefore on structure. Corroboration is found in the text:

... Knowledge one has acquired without sufficient structure to tie it together is knowledge that is likely to be forgotten.¹³

It is also apparent that Bruner wishes the reader to draw the inference that structure and theory are very much alike from a particular point of view: they are both aids to memory and vehicles for understanding. The two statements could be combined to read: Just as theory helps us to understand something and to retain what we have understood, so does structure. One cannot infer, however, that because structure and theory have similar characteristics, they are identical.

One concludes that a structure of knowledge like a pattern or a theory, helps one to understand something and to retain it once understood.

d) Structure--Genotype.- In the chapter on the proper use of teaching aids, Bruner discusses how some teaching aids help to grasp structure. He states:

A second type of teaching aid has the function of helping the student to GRASP the underlying STRUCTURE of a phenomenon--to SENSE THE GENOTYPE BEHIND THE PHENOTYPE,...¹⁴

¹³ Ibid., p. 31.

¹⁴ Ibid., p. 81.

In the above text, Bruner ventures into the field of genetics to show that an object of a cognitive operation in genetics is similar to the structure of a phenomenon as the object of the same type of cognitive operation. A transformation of the above could be: 'Just as one senses the genotype behind the phenotype so does one who grasps the underlying structure, sense high-level knowledge behind low-level information'.

The fact that one learns much low-level information does not mean that one has grasped the structure; this confirms one of the previous conclusions. To grasp structure involves seemingly a jump, a going beyond low-level information.

One can conclude, therefore, that an underlying structure of knowledge like a genotype implies that one has sensed high-level knowledge behind low-level information.

B. Second Evolving List of Derived Propositions

The conclusions reached in the analysis of the peripheral positive attributors may be summarized as follows: A structure of knowledge is somewhat like a general picture, somewhat like a model, somewhat like a pattern, somewhat like a theory, somewhat like a genotype.

- ¹⁰ It has a recognition attribute in that, like a general picture, it permits one to recognize the relations between things one encounters now as the same kind of relations between things one encountered earlier;

- 2⁰ It has a comprehension attribute in that like a model or a theory or a pattern, it is instrumental in understanding other things;
- 3⁰ It has a generative attribute, in that like a model it is instrumental in generating other things from it;
- 4⁰ It has a retention attribute in that like a pattern or a theory it helps one to retain what has been understood;
- 5⁰ It has a cognitive aspect in that like a genotype, it implies that one has sensed high-level knowledge behind low-level information.

How does the above relate to the first derived proposition which stated that 'a fundamental structure of knowledge is not only the knowledge of facts, of techniques, of specific topics and skills, of devices, of recipes; the knowledge of the above must be understood in the context of structure, etc.'?

There is nothing in the above set of positive conclusions which contradicts the first derived proposition. The conclusion that a structure of knowledge implies that one has sensed high-level knowledge behind low-level information is added to the first proposition since it shows by contrast what seems to be a significant aspect of a structure of knowledge. Other conclusions refer to the usefulness of a structure of knowledge; the analogies are grouped in proposition 2 and the utility aspects of a structure of knowledge which they bring out are grouped in proposition 3.

The second evolving list of derived propositions can thus be stated as follows:

Proposition 1: A fundamental structure of knowledge is not only the knowledge of facts, of techniques, of specific topics and skills, of devices, of recipes:

- a) knowledge of the above must be understood in the context of structure;
- b) specific topics and skills are uneconomical;
- c) devices and recipes are often applied without understanding their significance or connectedness;
- d) a fundamental internal structure of knowledge implies that one has sensed high-level knowledge behind low-level information.

Proposition 2: A fundamental structure of knowledge is somewhat like a general picture, somewhat like a model, somewhat like a pattern, somewhat like a theory, somewhat like a genotype:

- a) It has a recognition attribute in that, like a general picture it permits one to recognize the relations between things one encounters now as the same kind of relations between things one encountered earlier;
- b) it has a comprehension attribute in that, like a model or a theory or a pattern, it is instrumental in understanding other things;
- c) it has a generative attribute in that like a model, it is instrumental in generating other things

from it;

- d) it has a retention attribute in that like a pattern or a theory, it helps one to retain what has been understood;
- e) it has a cognitive aspect in that like a genotype, it implies that one has sensed high-level knowledge behind low-level information.

Proposition 3: A fundamental structure of knowledge is useful in:

- a) recognizing that the relations between things one encounters now are the same kind of relations between things one encountered earlier;
- b) comprehending other things;
- c) generating other things from it;
- d) retaining what has been understood.

From the peripheral attributors some aspects of a fundamental structure of knowledge have been identified. The next chapter deals with essential attributors which reflect Bruner's intent to circumscribe more precisely the concept of a structure of knowledge.

CHAPTER V

THE ESSENTIAL ATTRIBUTORS

This chapter purports to analyze the attributors by means of which the author of a communication wishes to convey the essential meaning of a pivotal entity by stating or at least by strongly intimating its physical and logical constituent parts and their connections.

There are three series of essential attributors by means of which Bruner attempts to explain the nature of a structure of knowledge. One series points to its material components; it comprises the sets 'structure-principles', 'structure-ideas', 'structure-ideas, principles, attitudes', 'structure-facts, information, principles, ideas'. The second series points to the formal components of a structure of knowledge: it comprises the sets 'structure-connectedness', 'structure-relatedness', 'structure-order', 'structure-meaning, significance', 'structure-general case'. The third series is really a series of one since there is but one attributor which explicitly refers to the logical aspect-- 'structure-symbolic system'.

As in the analysis of the peripheral attributors, for each series of essential attributors, the texts are quoted first followed by summaries, discussions and conclusions which focus on the notions pertinent to a reformulation of the

evolving list of derived propositions.

1. The Essential Attributors of the Material Components
of a Structure of Knowledge

- A. Analysis

In the context of teaching and learning Bruner uses a series of terms--principles, ideas, attitudes, facts, information--which suggests that the entities represented by these terms are constituent parts of a structure of knowledge.

Texts in which Bruner points to a 'rapprochement' between structure and ideas, between structure and principles, between structure and attitudes, are not always clear. A better understanding results, however, when the texts are simultaneously compared.

a) Structure--Principles.- A first text in which structure is related to principles reports Bruner's claim for emphasizing structure in teaching. He writes:

The fourth claim for emphasis on STRUCTURE AND PRINCIPLES in teaching is that by constantly reexamining material taught in elementary and secondary schools for its fundamental character, one is able to narrow the gap between 'advanced' knowledge and 'elementary' knowledge.¹

In the second text, Bruner refers to the way of constructing a curriculum and states:

¹ Jerome S. Bruner, The Process of Education, Cambridge, Harvard University Press, 1960, p. 25-26.

... the curriculum of a subject should be determined by the most fundamental understanding that can be achieved of the underlying PRINCIPLES THAT GIVE STRUCTURE to that subject.²

In the third text, Bruner attempts to convey the meaning of a principle or structure and states:

... To understand something as a specific instance of a more general case--which is what understanding a more fundamental PRINCIPLE OR STRUCTURE is ...³

One may summarize the three texts as follows: emphasis in teaching on structure and principles narrows the gap between elementary and advanced knowledge; fundamental principles give structure to a subject; understanding a fundamental principle or fundamental structure means to understand something as a specific instance of a more general case.

From the first statement, one surmises that structure and principles are two different but closely connected entities; from the second statement, that structure and principles are either in a cause-effect or a part-whole relationship, the ambiguity resulting from the difficulty of interpreting the action verb 'give'. Is a structure mastered by means of principles? Or are principles incorporated into a structure? Or are they constituent parts of structure?

2 Ibid., p. 31.

3 Ibid., p. 25.

It is not clear from the third statement taken by itself whether principles is the same kind of thing as structure or whether one is a subset of the other or whether one is the cause of the other. In the light of the first statement, however, principles and structure are different but closely related entities; one could therefore be a subset of the other or the cause of the other. It is not possible to determine at this point which of the last two alternatives is the correct one.

One concludes that: a fundamental structure and fundamental principles are two different but closely connected entities; they are either in a cause-effect or in part-whole relationship in the sense that one is a constituent part of the other.

b) Structure--Ideas.- The first text refers to Bruner's curriculum design proposal. He asks:

... What are the implications of emphasizing the STRUCTURE of a subject, be it mathematics or history--emphasizing it in a way that seeks to give a student as quickly as possible a sense of the fundamental IDEAS of a discipline.⁴

The second text is in connection with a type of teaching aid--model devices--which "has the function of helping the student to grasp the underlying structure of a phenomenon".⁵ He further states:

4 Ibid., p. 3.

5 Ibid., p. 81.

... A closer look at our efforts to get students to grasp STRUCTURE indicates that there are many other devices and exercises that have the same function. The effort to give visible embodiment to IDEAS in mathematics is of the same order as the laboratory work.⁶

Finally, the third text is extracted from a discussion on the importance of a well-conceived sequence in any curriculum. Bruner gives examples of curricula which, in his opinion, have that characteristic and states:

... the courses being devised by the University of Illinois Committee on School Mathematics, the School Mathematics Study Group, the Physical Science Study Committee, and others are excellent instances of the well-conceived sequence designed to lead the student to an understanding of basic IDEAS and STRUCTURES.⁷

The three texts may be summarized as follows: it is important for students to understand the fundamental structure and fundamental ideas of a discipline; the embodiment of the basic ideas of a discipline in model devices helps students to grasp its structure; the emphasis on structure in teaching gives students a sense of the fundamental ideas of a discipline.

From these summary statements one concludes that: fundamental structure and fundamental ideas are two different but closely connected entities; a fundamental structure of knowledge has more extension than fundamental ideas.

6 Ibid., p. 81.

7 Ibid., p. 82.

c) Structure--Principles, Ideas, Attitudes.- There is a number of texts in The Process of Education in which the words 'ideas', 'principles', 'attitudes' are jointly used. In this section, the objectives are to attempt to determine by a comparison of the texts, first whether the entities are different; secondly, whether the relationships amongst ideas, principles, attitudes can be inferred; thirdly, whether relationships between ideas, principles, attitudes, and structure other than those found in the previous section, can be determined.

In several texts, the recurrent theme is transfer. Bruner distinguishes between two types of transfer: specific transfer i.e. the extension of habits and skills, and non-specific transfer. He describes non-specific transfer as follows:

... A second way in which earlier learning renders later performance more efficient is through what is conveniently called non-specific transfer or, more accurately, the transfer of PRINCIPLES and ATTITUDES. In essence, it consists of learning initially not a skill but a general IDEA, which can then be used as a basis for recognizing subsequent problems as special cases of the idea originally mastered.⁸

The second text is taken from the same context. He writes:

8 Ibid., p. 17.

The continuity of learning that is produced by the second type of transfer, transfer of PRINCIPLES, is dependent upon mastery of the structure of the subject-matter [...] That is to say, in order for a person to be able to recognize the applicability of inapplicability of an idea to a new situation and to broaden his learning thereby, he must have clearly in mind the GENERAL NATURE of the phenomenon with which he is dealing. The more fundamental or basic is the IDEA he has learned, almost by definition, the greater will be its breadth of applicability to new problems. Indeed, this is almost a tautology, for what is meant by 'FUNDAMENTAL' in this sense is precisely that an idea has wide as well as powerful applicability.⁹

But one encounters serious problems in devising curricula geared to the teaching of fundamental ideas. Thus, Bruner mentions that:

There is at least one major matter that is left unsettled even by a large-scale revision of curricula in the direction indicated. Mastery of the FUNDAMENTAL IDEAS of a field involves not only the grasping of GENERAL PRINCIPLES, but also the development of an ATTITUDE toward learning and inquiry, toward guessing and hunches, toward the possibility of solving problems on one's own.¹⁰

The fourth text is taken from a section in which Bruner discusses the claims for teaching structure:

... an understanding of FUNDAMENTAL PRINCIPLES AND IDEAS [...] appears to be the main road to adequate 'transfer of training' [...] A carefully wrought understanding should also permit him to recognize the limits of the GENERALIZATION as well. The idea of 'PRINCIPLES' and 'CONCEPTS' as a basis for transfer is hardly new.¹¹

9 Ibid., p. 18.

10 Ibid., p. 20.

11 Ibid., p. 25.

The following short statements give the gist of the information obtained from the above texts: non-specific transfer can be described as the transfer of principles and attitudes; in non-specific transfer, one has learned an idea that can be used as a basis for recognizing subsequent problems as special cases of the idea originally mastered; the transfer of fundamental principles is dependent upon mastery of the structure of the subject matter; one must have clearly in mind the general nature of a phenomenon to recognize the applicability or inapplicability of an idea; the more fundamental the idea, the greater its breadth of applicability; a fundamental idea has wide and powerful applicability; mastery of the fundamental ideas of a field involves the grasping of general principles and the development of attitudes; an understanding of fundamental principles and ideas appears to be the main road to transfer; principles and concepts are the basis for transfer.

It is apparent that fundamental ideas, fundamental principles, and attitudes are different entities with fundamental structure probably subsuming all of them. Moreover, the implications are that these entities are jointly present in non-specific transfer.

But almost 'en passant' and in the same context, Bruner mentions that 'the idea of principles and concepts as a basis for transfer is hardly new'. Though Bruner does not

always qualify 'ideas', it is obvious from the context that concepts and ideas are meant to be equivalent terms. In other contexts, principles and ideas, structure and ideas are near-synonyms. Yet, from the above texts, it is reasonable to assume that fundamental structure has more extension than fundamental ideas, that a fundamental idea has greater extension than a fundamental principle, that a fundamental principle has greater extension than the specific ideas of which it consists.

With respect to attitudes, though they do not seem to belong to the series of entities, one must assume that Bruner is thinking of an accompanying cognitive mental set since they are mentioned in conjunction with principles and ideas.

To recapitulate, one can say: that fundamental structure, fundamental ideas, fundamental principles and attitudes are different entities; that a fundamental structure of knowledge makes the transfer of principles possible; that attitudes refer to a cognitive mental set.

d) ~~Structure-Facts~~, Information, Principles, Ideas.- Bruner directly relates structure to facts, information, principles, ideas. In a description of the advantages of teaching specific topics or skills by making clear their context in the broader fundamental structure of a field, he states:

... knowledge one has acquired without sufficient STRUCTURE to tie it together is knowledge that is likely to be forgotten. An UNCONNECTED SET OF FACTS has a pitifully short half-life in memory. ORGANIZING FACTS in terms of PRINCIPLES AND IDEAS from which they may be inferred is the only known way of reducing the quick rate of loss of human memory.¹²

The following statements summarize the above text: structure ties facts together by organizing them in terms of principles and ideas; connected facts help memory. Only the first statement is of interest at this time. It can be linked to the analysis of the peripheral attributors from which was drawn the conclusion that 'a structure of knowledge is not only knowledge of facts, etc.'. It is not as exclusive as it might appear at first glance. Facts are not unrelated to structure; in point of fact, structure ties them together. What Bruner wishes to emphasize is that acquisition and mastery¹³ of facts is not sufficient. This interpretation is confirmed in the following text in which Bruner describes the processes involved in the act of learning in a learning episode:

There is a range of problems that have to do with how much emphasis should be placed on ACQUISITION, transformation, and evaluation in a learning episode --GETTING FACTS, manipulating them, and checking one's ideas...¹⁴

12 Ibid., p. 31-32.

13 Ibid., p. 12.

14 Ibid., p. 50.

Getting facts is but one step in the act of learning but it is a step. Once the facts (or information) have been acquired¹⁵ the learner must transform them or manipulate them in order to go beyond them.¹⁶

This leads to the following conclusion: structure implies that acquired facts (or information) have been ordered or tied together in terms of principles and ideas through the process of transformation.

B. Third Evolving List of Derived Propositions

The conclusions reached in the analysis of the first series of essential attributors may be summarized as follows:

- 1⁰ Fundamental structure, fundamental principles, fundamental ideas and attitudes are different but closely related entities.
 - Structure and principles are either in a cause-effect or in a part-whole relationship;
 - Fundamental ideas subsume principles and attitudes;
 - Attitudes refer to a cognitive mental set;
 - A fundamental structure probably subsumes fundamental ideas;
 - Fundamental principles and ideas have wide and powerful applicability and therefore make non-specific transfer possible.
- 2⁰ A fundamental structure of knowledge implies that acquired facts (or information) have been organized

15 Ibid., p. 48.

16 Ibid., p. 48.

in terms of principles and ideas through the process of transformation.

One now attempts to incorporate the conclusions reached in this series of essential attributors to the second evolving list of derived propositions in order to maintain it, to correct it, to reject it, to add to it, to delete from it.

First, the conclusion that 'a fundamental structure of knowledge implies that acquired facts (or information) have been organized in terms of principles and ideas through the process of transformation' adds precision to the sub-proposition of Proposition 1 of the second evolving list of derived propositions which states 'that a fundamental structure of knowledge implies that one has sensed high-level knowledge behind low-level information'.

Second, while the conclusion 'that fundamental structure, fundamental principles, fundamental ideas, and attitudes have wide and powerful applicability and therefore make non-specific transfer possible' should be retained within the first major conclusion, it should also be incorporated to the third proposition of the second evolving list of derived propositions because it states the reason for its usefulness in recognizing a situation or problem as an instance of it.

With these amendments, the third evolving list of derived propositions is now constituted of the following:

Proposition 1: A fundamental structure of knowledge is not only the knowledge of facts, of techniques, of specific topic and skills, of devices, of recipes.

- a) Knowledge of the above must be understood in the context of structure;
- b) specific topics and skills are uneconomical;
- c) devices and recipes are often applied without understanding their significance or connectedness;
- d) a fundamental structure of knowledge implies that high-level knowledge has been sensed behind low-level information, that acquired facts (or information) have been organized in terms of principles and ideas through the process of transformation.

Proposition 2: Same as proposition 2 of the second evolving list of derived propositions.

Proposition 3: A fundamental structure of knowledge, is useful in:

- a) recognizing, because of its breadth of applicability, that the relations between things one encounters now are the same kind of relations between things one encountered earlier;
- b) comprehending other things;
- c) generating other things from it;

d) retaining what has been understood;

Proposition 4: Fundamental structure, fundamental principles, fundamental ideas and attitudes are different but closely related entities. Specifically:

- a) structure and principles are either in a cause-effect or in a part-whole relationship;
- b) fundamental ideas subsume principles and attitudes;
- c) attitudes refer to a cognitive mental set;
- d) a fundamental structure probably subsumes fundamental ideas;
- e) fundamental principles and ideas have wide and powerful applicability and therefore make non-specific transfer possible.

2. The Essential Attributors of the Formal Components of a Structure of Knowledge

A. Analysis

Some attributors used in conjunction with structure give an intimation of the meaning of structure. The entities that these attributors represent point more directly to some aspect of a structure of knowledge; they are attempts to go to the heart of the matter. The attributors may be converted into the form: "Grasping a structure of knowledge means the same thing as ...". Connectedness, order, relatedness,

meaning, significance, general case are in that category.

a) Structure--Connectedness.- In a recapitulation of the chapter on the importance of structure in curriculum design, Bruner restates one of the claims for teaching structure, namely, a help to memory. He explains:

... knowledge one has acquired without sufficient STRUCTURE to tie it together is knowledge that is likely to be forgotten. An UNCONNECTED SET OF FACTS has a pitifully short half-life in memory. ORGANIZING FACTS in terms of principles and ideas from which they may be inferred is the only known way of reducing the quick rate of loss of human memory.¹⁷

The second text, in the same context, reinforces the first:

... whether an examination is of the 'objective' type involving multiple choices or of the essay type, it can be devised so as to emphasize an understanding of the broad PRINCIPLES of a subject. Indeed, even when one examines on detailed knowledge, it can be done in such a way as to require an understanding by the student of the CONNECTEDNESS BETWEEN SPECIFIC FACTS...¹⁸

The idea of connectedness is also emphasized in the learning of attitudes: "the attitude that things are CONNECTED...".¹⁹

The above texts are summarized as follows: a structure ties knowledge together; facts which are connected are

17 Ibid., p. 31-32.

18 Ibid., p. 30-31.

19 Ibid., p. 27.

retained longer; facts, to be retained, must be organized in terms of principles and ideas; to learn structure is to learn how things are connected.

It is obvious from the above statements that a structure of knowledge implies that facts express the connectedness of things and are themselves connected in terms of principles and ideas.

b) Structure--Order.- In connection with the teaching of children who have not yet attained, in Piaget's terms, the formal operations stage, Bruner introduces the question of economy of teaching. He asks:

Is it worthwhile to train the young inductively so that they may discover the basic ORDER of knowledge before they can appreciate its formalism?²⁰

In the chapter on the balance in teaching between intuitive and analytic thinking, Bruner links connectedness and order to structure. He states:

In this connection we may ask whether, in teaching, emphasis upon the STRUCTURE OR CONNECTEDNESS OF KNOWLEDGE increases facility in intuitive thinking. Those concerned with the improvement of the teaching of mathematics often emphasize the importance of developing in the student an understanding of the STRUCTURE OR ORDER of mathematics.²¹

In the same chapter, Bruner states that intuition yields hypotheses quickly. He adds:

²⁰ Ibid., p. 47.

²¹ Ibid., p. 62-63.

... In the end, intuition by itself yields a tentative ORDERING of a body of knowledge that, while it may generate a feeling that the ORDERING OF FACTS is self-evident, aids principally by giving us a basis for moving ahead in our testing of reality.²²

The statements which summarize the texts of this section are as follows: the basic order of knowledge may be discovered by children before they can appreciate its formalism; structure or connectedness of knowledge may increase facility in intuitive thinking; it is important to develop in the student an understanding of the structure or order of knowledge; intuition yields a tentative ordering of knowledge.

Within the perspective of this chapter, what do the above statements suggest concerning a structure of knowledge and the terms used to convey that notion? Structure, connectedness and order are intended as near-synonyms. If one relies on the dictionary meaning of these terms, connectedness implies a link between things, and order implies regular and harmonious (congruous) relations between things. Order adds the notion of regularity and congruousness to connectedness regardless of the manner it is attained--intuitively or analytically.

The above considerations permit one to conclude that a structure of knowledge implies at least a connection between facts and, at a higher level, regular and congruous relations

²² Ibid., p. 60.

between facts and fundamental principles both of which are objects of knowledge.

c) Structure--Meaning, Significance.- In his explanation of the nature of intuition, Bruner states:

... Intuition implies the act of grasping the MEANING, SIGNIFICANCE, or STRUCTURE of a problem or situation without explicit reliance on the analytic apparatus of one's craft...²³

In a different context, namely, the trends in American psychology concerning learning, Bruner again coordinates significance and structure.

... In consequence, [of emphasis on acquisition of specific skills] there was relatively little work by American psychologists during the first four decades of this century on the manner in which the student could be trained to grasp the underlying STRUCTURE OR SIGNIFICANCE of complex knowledge.²⁴

From these two texts, one derives the following statements: intuition implies the act of grasping the meaning, significance, or structure of a problem or situation without explicit reliance on analysis; American psychologists, during the first decades of the century, did little work on the manner in which the student could be trained to grasp the underlying structure or significance of complex knowledge.

There is no other kind of direct internal support for interpreting the meaning of meaning and significance in

23 Ibid., p. 60.

24 Ibid., p. 6.

relation to structure. However, if one attends to the senses of 'meaning' and 'significance' as given in the dictionary, one finds that one of the senses of 'meaning' is 'significance' a word which applies to "a meaning often covert rather than ostensible regarded as of weight or importance".²⁵ The activity of grasping the meaning as suggested by Bruner in the above texts, is not one of grasping the meaning of a word but the meaning of a problem or situation or complex knowledge. What the student must grasp therefore is the covert meaning of a problem or situation or complex knowledge. Logically, this supposes that meaning has already been acquired and that one goes beyond it "to a description of what else might occur".²⁶ As a result, various aspects of a thing (characteristics, effects, etc.) are placed in relationship with each other.

This provides a possible clue to Bruner's appositional use of 'meaning', 'structure' and 'significance' in the sense that 'just as meaning (or more precisely significance) implies going beyond what is immediately apparent in a problem, etc., to various aspects of a thing placed in relationship with each other, so does structure'. This points to some aspect

²⁵ Webster's New International Dictionary, Second Edition, Springfield, Mass., G. & C. Merriam Company, 1959, p. 1520.

²⁶ Bruner, Op. Cit., p. 37.

of the nature of structure.

From this discussion, one concludes that: a structure of knowledge at least partially refers to objects of knowledge from which one can make some hypothetical statements concerning their other characteristics, effects and so on.

d) Structure--Relatedness.- In the conclusion to a description of an example by means of which Bruner purports to define structure, he states:

... Grasping the STRUCTURE of a subject is understanding it in a way that permits many other things to be RELATED to it meaningfully. To learn structure, in short, is to learn how things are RELATED.²⁷

Bruner again refers to the idea of relatedness in the following statement:

If earlier learning is to render later learning easier, it must do so by providing a general picture in terms of which the RELATIONS between things encountered earlier and later are made as clear as possible.²⁸

The text could be transformed into two univocal equivalent contexts: grasping the structure of a subject means the same thing as understanding it in a way that permits many other things to be related to it meaningfully; to learn structure means the same thing as to learn how things are related.

27 Ibid., p. 7.

28 Ibid., p. 12.

Bruner emphasizes that relations are involved in structure. There is also the implication that structure is a focal entity which rallies particular things to it meaningfully, i.e., in such a way that one can go beyond it to other characteristics, effects, etc.

In the second transformation, neither the nature of the relationship nor the kinds of things related are explicated, though relationships are again emphasized.

From the discussion, one concludes that: a structure of knowledge involves relations; a structure of knowledge permits one to relate other things to it meaningfully.

e) Structure--General case.- In the larger context of transfer Bruner writes the following text:

... to understand something as a SPECIFIC INSTANCE OF A MORE GENERAL CASE--which is what understanding a more fundamental PRINCIPLE OR STRUCTURE means...²⁹

The text could be transformed to read: Understanding a more fundamental principle or structure means the same thing as understanding something as a specific instance of a more general case.

Bruner illustrates by means of an example which is paraphrased thusly: Once one has gone beyond the facts that the Hundred Years' War resulted from a difference in ideologies and eventually culminated in a treaty, to the principle

²⁹ Ibid., p. 25.

(or structure? or general case?) that struggle and eventually conditions for compromise result from differences in ideologies, one can now recognize the East-West conflict as an instance of that principle (or structure? or general case?) "though the parallel is anything but exact".³⁰

It is unfortunate that Bruner used the two words 'principles' and 'structure' in this text. Had Bruner used either 'structure' or 'principle' but not both, one could have determined to some extent the meaning of at least one term. As it is the reader is left in a quandary. Are 'principle' and 'structure' two equivalent terms? Are they in a part-whole relationship? Or are they in some other kind of relationship? Previous analyses established that principles and structures were two different entities; but it is still impossible to determine the relationship between the two.

The confusion is compounded in the following text, which is also about transfer, but in which Bruner uses the word 'ideas':

... In essence, it [learning of principles and attitudes] consists in learning initially not a skill but a GENERAL IDEA, which can then be used as a basis for recognizing subsequent problems as special cases of the idea originally mastered.³¹

30 Ibid., p. 25.

31 Ibid., p. 17.

The conclusion derived from the above can therefore only be very ambiguous: A fundamental structure of knowledge (or principle? or idea?) is used to recognize something as a specific instance of a more general case.

B. Fourth Evolving List of Derived Propositions

The conclusions reached in this analysis of the second series of essential attributors may be summarized as follows:

- 1⁰ A structure of knowledge implies that known facts express the connectedness of things and are themselves connected in terms of principles and ideas.
- 2⁰ A structure of knowledge implies at least a connection between facts and, at a higher level, regular and congruous relations between facts and principles both of which are objects of knowledge.
- 3⁰ A structure of knowledge at least partially refers to objects of knowledge from which one can make some statements concerning their other characteristics, effects, and so on.
- 4⁰ A structure of knowledge permits one to relate other things to it meaningfully.
- 5⁰ A structure of knowledge (or principle? or idea?) is used to recognize something as a specific instance of a more general case.

How do these conclusions compare with the propositions of the third evolving list of derived propositions?

First, the third evolving list stated that 'a fundamental structure of knowledge is not only the knowledge of facts, of techniques, etc.' and that it 'implies that acquired facts (or information) have been organized in terms of principles

and ideas through the process of transformation'. The first conclusion above adds that facts express the connectedness of things. This suggests that a fundamental structure supposes the connectedness of things as expressed in facts and a connection between facts in terms of principles and ideas.

Second, the third evolving list of derived propositions also stated that 'fundamental structures, fundamental ideas and fundamental principles and attitudes are closely related entities'. The second conclusion above provides clues for a distinction between these entities and others since it suggests that there are two levels of knowledge. One would have to conjecture that, at the first level, facts express a connection between specific ideas; a fact, therefore, consists of elementary ideas in relation. One would also have to conjecture that the connection established between ideas and things and expressed in a statement of fact constitutes an elementary structure of knowledge. At the second level, one would find fundamental structures, fundamental principles and fundamental ideas. One can conjecture that this means that relations must be established between specific facts and principles and that relations must also be established between elementary ideas and fundamental ideas. Consequently, there are different levels of structures; some are elementary, others are fundamental. This would also help to clarify the conclusion 'that a fundamental

structure of knowledge (or principle? or idea?) is used to recognize something as a specific instance of a more general case'; a fundamental structure, a fundamental principle, a fundamental idea are all general cases whose specific instances are respectively, a more elementary structure, a specific fact, an elementary idea. Further, it explains a sub-proposition of the third evolving list 'that structure of knowledge is useful in comprehending other things'.

Thirdly, these conjectures can be checked against the following propositions of the third evolving list of derived propositions: 'structure probably subsumes ideas', 'principles and structures are either in a cause-effect or in a part-whole relationship'. As to the first of these sub-propositions, it is congruent with the conjectures above, as a structure is a more complex entity than ideas though it is closely related to them. The second is disjunctive and therefore inconclusive, but if a structure of knowledge 'implies regular and congruous relations between facts and principles', it follows that principles are constituent parts of a fundamental structure. This sub-proposition should now be changed to 'principles are a constituent part of a fundamental structure of knowledge'.

Fourthly, one must incorporate to the list of propositions the conclusion which makes the point 'that from a fundamental structure of knowledge one can make hypothetical

statements concerning other observable characteristics, effects, etc. of objects of knowledge'. This seems to be what is implied in the sub-proposition of the third evolving list 'that a fundamental structure of knowledge is useful in generating other things from it'.

Fifthly, one must bring out what seems to be a distinctive component of a fundamental structure of knowledge, namely, the idea of regular and congruous relations between two objects of knowledge at different levels.

Sixthly, the conclusion that 'a structure of knowledge permits one to relate other things to it meaningfully' has strong affinity with the sub-proposition that 'a structure of knowledge is useful in comprehending things'.

Finally, there is no reason not to retain the other propositions of the third evolving list of derived propositions. Of course, one must again assume that what applies to a structure of knowledge also applies to a fundamental structure, though one must recognize that there is at least a difference of levels and breadth of applicability between elementary and fundamental structures.

The fourth evolving list of derived propositions can now be stated as follows:

Proposition 1: A fundamental structure of knowledge is not only the knowledge of facts, of techniques, of specific topics and skills, of devices, of recipes.

- a) Facts express the connectedness of things;
- b) knowledge of facts must be understood in the context of structure;
- c) specific topics and skills are uneconomical;
- d) devices and recipes are often applied without understanding their significance or connectedness;
- e) a fundamental structure of knowledge implies that high-level knowledge has been sensed behind low-level information and that acquired facts (or information) have been organized or connected in terms of principles and ideas through the process of transformation.

Proposition 2: Same as proposition 2 of the second and third evolving list of derived propositions.

Proposition 3: A fundamental structure of knowledge is useful in:

- a) recognizing, because of its breadth of applicability
 - that relations between things one encounters now are the same kind of relations between things one encountered earlier;
 - that something is a specific instance of a more general case;
- b) comprehending other things, i.e. it makes other things understandable;
- c) generating other things from it, i.e. in

hypothesizing other observable characteristics, effects, etc. about something;

d) retaining what has been understood.

Proposition 4: Fundamental structure, fundamental principles, fundamental ideas and attitudes are different but closely related entities. Specifically

- a) fundamental principles are a constituent part of a fundamental structure of knowledge;
- b) fundamental ideas subsume fundamental principles and attitudes;
- c) attitudes refer to a cognitive mental set;
- d) a fundamental structure probably subsumes fundamental ideas;
- e) fundamental principles and ideas have wide and powerful applicability and therefore make non-specific transfer possible.

Proposition 5: A fundamental structure of knowledge implies at least a connection between facts and, at a higher level, regular and congruous relations between facts and principles both of which are objects of knowledge.

3. The Essential Attributors of the Logical Components of a Structure of Knowledge.

The author of a communication may wish to indicate to the reader or listener the class to which a pivotal entity belongs and the manner by which it is to be distinguished from members in the same class.

The attributors to convey that kind of meaning would likely be found in sentences in which the subject is the pivotal entity, the verb a copula, and the predicate an abstract noun sometimes accompanied by a sortal adjective, e.g. 'man is an animal', 'man is a rational animal'.

A. Analysis

While it was possible to find several attributors which pointed to the physical components of a structure of knowledge there is but one attributor which could be construed as an attributor of its logical components.

In a discussion on intellectual development in which he reports extensively on the work of Piaget, Bruner states:

With the advent of concrete operations, the child develops an internalized STRUCTURE WITH WHICH TO OPERATE. In the example of the balance scale, the STRUCTURE IS A SERIAL ORDER OF WEIGHTS that the child has in his mind. Such internal structures are of the essence. THEY ARE THE INTERNALIZED SYMBOLIC SYSTEMS BY WHICH THE CHILD REPRESENTS THE WORLD, as in the example of the pinball machine and the angles of incidence and reflection...³²

³² Ibid., p. 36-37.

Transformation of the above text yields the following statements: there are internal structures; an internal structure is an internalized symbolic system by which the world is represented and with which one operates; an internal structure in the case of a balance scale is a serial order of weights.

Coming to grips with the above statements is fraught with difficulties. First, this is the only instance in which Bruner specifically qualifies structure as internal. Yet there is no doubt that his major intent throughout The Process of Education is to communicate something about internal structures as opposed to what one could label external structures. Internal structures are within the individual; they imply a cognitive activity which Bruner indifferently describes as grasping,³³ or understanding,³⁴ or learning³⁵ structures. One must therefore distinguish between the activity of the subject (grasping, understanding, learning) and the object of this activity (structures).

Second, the statement that an internal structure is an internalized symbolic system is so general that it paradoxically says everything and nothing about the pivotal

33 Ibid., p. 6, 7, 8, 60, 81.

34 Ibid., p. 11, 63, 82, 84.

35 Ibid., p. 7, 8, 12.

entity. It supposes that Bruner and his reader have equivalent meanings of the class 'system' and its qualifier 'symbolic'; that is not necessarily the case.

Third, from the second statement, it is apparent that structure has two uses: it is a system with which we operate and by means of which we represent the world. Which is the antecedent, which the consequent is not obvious. Does one operate with structure because it represents the world? Or is structure a means of representing the world because one has operated? A positive answer can be given to both questions. If the way one looks at some phenomenon represents the result of an operation³⁶ then structure understood as a system by which the world is represented is the result of an operation and one would have to say that once developed through operations, the structure becomes a means with which to operate.³⁷ The examples given by Bruner seem to confirm this interpretation: in the example of the balance scale, the structure is a serial order of weights which the child has represented in his mind; in the example of the pinball machine, the structure is a representation of a rough, or fixed, or equal (depending on the stage of operations) relationship between the angle of incidence and

36 Ibid., p. 34.

37 Ibid., p. 34.

reflection.

From this discussion, one can accept the conclusion that a structure of knowledge is an internalized symbolic system by which one first represents the world as a result of operations and then with which one operates.

B. Fifth Evolving List of Derived Propositions

The above conclusion is a key statement in the analysis of attributors for two reasons.

First, it is not of the same order as the other conclusions in the sense that something is said about structure not by reference to what might constitute its physical components or by reference to entities of a similar nature but by relating it to what apparently is a larger class--symbolic systems.

Second, the conclusion applies to all forms of structures, fundamental or otherwise. Each way one has of representing the world as a result of operations is a structure. Since the concern of this research is with a fundamental internal structure of knowledge, one could restate the conclusion to read: A fundamental internal structure of knowledge is an internalized symbolic system by which the world is represented and with which one operates.

As a consequence, the qualifier 'internal' can now legitimately be added to the introductory phrase in each

proposition of the fourth evolving list of derived propositions. Also, the conclusion itself becomes a proposition of the fifth evolving list.

Proposition 5 of the fourth evolving list must be revised even more in the light of the distinction made between the activity of the subject and the object of such activity. It can now be stated as follows: A fundamental internal structure of knowledge implies, a) objectively, at least a connection between facts and, at a higher level, regular and congruous relations between facts and fundamental principles and b) subjectively, the activity of grasping, or understanding, or learning of these connections and relations.

The fifth evolving list of derived propositions can now be stated as follows:

Proposition 1: A fundamental internal structure of knowledge is not only the knowledge of facts, of techniques, of specific topics and skills, of devices, of recipes:

- a) Facts express the connectedness of things;
- b) knowledge of facts must be understood in the context of structure;
- c) specific topics and skills are uneconomical;
- d) devices and recipes are often applied without understanding their significance or connectedness;
- e) a fundamental internal structure of knowledge

implies that high-level knowledge has been sensed behind low-level information and that acquired facts (or information) have been organized or connected in terms of principles and ideas through the process of transformation.

Proposition 2: A fundamental internal structure of knowledge is somewhat like a general picture, somewhat like a model, somewhat like a pattern, somewhat like a theory, somewhat like a genotype:

- a) it has a recognition attribute in that, like a general picture, it permits one to recognize the relations between things one encounters now as the same kind of relations between things encountered earlier;
- b) it has a comprehension attribute in that, like a model or a theory or a pattern, it is instrumental in understanding other things;
- c) it has a generative attitude in that like a model, it is instrumental in generating other things from it;
- d) it has a retention attribute in that like a pattern or a theory, it helps one to retain what has been understood;
- e) it has a cognitive aspect in that, like a genotype, it implies that one has sensed high-level knowledge

behind low-level information.

Proposition 3: A fundamental internal structure of knowledge is useful in:

- a) recognizing, because of its breadth of applicability,
 - that relations between things one encounters now are the same kind of relations between things one encountered earlier;
 - that something is a specific instance of a more general case.
- b) comprehending other things, i.e., it makes other things understandable;
- c) generating other things from it, i.e. in hypothesizing other observable characteristics, effects, etc. about something;
- d) retaining what has been understood.

Proposition 4: A fundamental internal structure, fundamental principles, fundamental ideas and attitudes are different but closely related entities.

Specifically,

- a) fundamental principles are a constituent part of a fundamental internal structure of knowledge;
- b) fundamental ideas subsume fundamental principles and attitudes;
- c) attitudes refer to a cognitive mental set;
- d) a fundamental internal structure probably subsumes

fundamental ideas;

- e) fundamental principles and ideas have wide and powerful applicability and therefore make non-specific transfer possible.

Proposition 5: A fundamental internal structure of knowledge implies

- a) objectively, at least a connection between facts and, at a higher level, regular and congruous relations between facts and fundamental principles and
- b) subjectively, the activity of grasping, or understanding, or learning of these connections and relations.

Proposition 6: A fundamental internal structure of knowledge is an internalized symbolic system

- a) which is the result of operations;
- b) by means of which the learner first represents his view of the world;
- c) with which the learner then operates on its variants.

The essential attributors have yielded important statements concerning the nature of a fundamental structure of knowledge. To explain more concretely the meaning of a fundamental structure, Bruner uses examples, which have been called 'denotative attributors'; in this research they constitute the object of study of the next chapter.

CHAPTER VI

THE DENOTATIVE ATTRIBUTORS

In chapters IV and V, an identification of the peripheral and essential attributors of a structure of knowledge and their possible relationships to one another was attempted. The conclusions and the evolving list of derived propositions under which the conclusions were regrouped reflect the findings.

An analysis of the examples Bruner gives of a structure of knowledge is done at this point for two reasons: it is logically more appropriate to know the nature of something before knowing its attributes, its factors, etc.; a study of the attributes and factors to be taken up in the following chapters is more meaningful if one understands them in the light of the nature of a structure of knowledge.

Denotative attributors concretely represent some aspect of the nature of the thing to which the speaker wishes to call attention and the language used is usually less abstract. There is, of course, the danger that one might not attend to the aspect of the thing that the speaker wishes to emphasize. If, however, sufficient examples are given and analyzed, the probability that the concept will be reached is increased. Only those examples which Bruner gives as explaining what he means by structure are considered here.

For each example, the text which reports the example is quoted first followed by an analysis. From the analysis, a conclusion is reached concerning a structure of knowledge. This is followed by a discussion of the conclusions in relation to the fifth evolving list of derived propositions. Finally a new evolving list of derived propositions is stated.

In the course of the analyses, a number of terms are used to express the entities Bruner is talking about. The first section of this chapter deals therefore with the definitions of terms used in the analysis; the second section reports the specific analysis of the examples.

1. Definitions of Terms Used in the Analysis

The terms are stated first followed by the definitions.

Set: an entity containing a number of things of the same kind or a collection of relations that belong together or both.

Relation: a reference or bearing of one term to another on some basis.

Elements: any identifiable meaningful part of a set.

Statement: a set of elements placed in closely connected relationships and expressing an intended meaning.

Particular statement: a statement in which the intended meaning is low-level knowledge.

Universal statement: a statement in which the intended meaning is high-level knowledge.

Specific elements: any identifiable meaningful part of a particular statement.

Typical elements: any identifiable meaningful part of a universal statement.

Specific relations: relations between specific elements in a particular statement.

Typical relations: relations between typical elements in a universal statement.

Abstraction: the act of dropping the differences between specific elements and retaining only their similar aspects.

Generalization: either a process or a product; as a process, it is an operation which consists in extending to a class of things the relations perceived or observed between them; as a product, it expresses either a state of affairs or a principle in the form of a universal statement.

2. Specific Analysis of the Examples

The following text from The Process of Education introduces the three sets of examples by means of which Bruner wishes to make the idea of structure clearer.

A word is needed at this point to explain in fuller detail what is meant by the STRUCTURE of a subject, for we shall have occasion to return to this idea often in later pages. Three simple examples--from biology, from mathematics, and from the learning of language--help to make the idea clearer.¹

A. The Biology Example

The text for this example is the following:

¹ Jerome S. Bruner, The Process of Education, Cambridge, Harvard University Press, 1960, p. 6.

... Take first a set of observations on an inchworm crossing a sheet of graph paper mounted on a board. The board is horizontal; the animal moves in a straight line. We tilt the board so that the inclined plane or upward grade is 30° . We observe that the animal does not go straight up, but travels at an angle of 45° from the line of maximum climb. We now tilt the board to 60° . At what angle does the animal travel with respect to the line of maximum climb? Now, say, he travels along a line of 75° off the straight-up line. From these two measures, we may infer that inchworms 'prefer' to travel uphill, if uphill they must go, along an incline of 15° . We have discovered a tropism, as it is called, indeed a geotropism. It is not an isolated fact. We can go on to show that among simple organisms, such phenomena--regulation of locomotion according to a fixed or built-in standard--are the rule. There is a preferred level of illumination toward which lower organisms orient, a preferred level of salinity, of temperature, and so on. Once a student grasps this basic relation between external stimulation and locomotor action, he is well on his way toward being able to handle a good deal of seemingly new but, in fact, highly related information. The swarming of locusts where temperature determines the swarm density in which locusts are forced to travel, the species maintenance of insects at different altitudes on the side of a mountain where crossbreeding is prevented by the tendency of each species to travel in its preferred oxygen zone, and many other phenomena in biology can be understood in the light of tropisms. Grasping the structure of a subject is understanding it in a way that permits many other things to be related to it meaningfully. To learn structure, in short, is to learn how things are related.²

The expressions to focus on in the first part of the example are: [From a] "set of observations [...] we may infer [that we] [...] have discovered a tropism". One observes that the tropism places in close relationship four types of specific

² Ibid., p. 6-7.

entities as expressed in the particular statement: inchworms (element) tend to travel (relation) if uphill they must go (element) at an incline of 15^0 (element). The starting point of the inference is therefore a set of elements in relationship as expressed by a tropism itself inferred from a set of observations.

The expression "It is not an isolated fact" draws attention to many other instances of such tropisms (about locusts, B insects, etc.).

From this set of tropisms, one goes on to a recognition of the similarity of attributes of the specific elements to a typical element and to a recognition of the similarity of the specific relations between specific elements to the typical relations between typical elements.

Thus, from each set of specific elements (e.g. inchworms, locusts, B insects, etc.), a typical element (e.g. some simple organisms) is abstracted.

Each set of specific relations is generalized (as process) to a typical relation. There are two kinds of specific relations: one is a main relation between the subject and predicate (e.g. between 'inchworms' and 'uphill they must go at an angle of 15^0 ') and the other is a secondary relation between two elements in the predicate (e.g. between 'uphill they must go' and 'at an angle of 15^0 ').

A major generalization (as process) is drawn from a set of main specific relations of the tropisms to their typical relation (e.g. from 'have a tendency to travel' applicable individually to 'inchworms', to 'locusts' etc. to 'have a tendency to travel' applicable to 'some simple organisms'). Similarly, a minor generalization is drawn from a set of secondary specific relations.

The result is a generalization as a product, a tropic response: 'Some simple organisms have a tendency to travel in a certain invariant way to given constant external stimuli'. All other information can be related to this generalization.

The major generalization as process brings about the structure and the major generalization as a product embodies the structure. This network of relations therefore between tropisms and tropic response constitutes the dynamic component of a structure in biology.

The tropic response (generalization as a product) can now be used as a rule of operation to handle other facts of a similar nature.

B. The Language Examples

Concerning language, the text to be analyzed is the following:

The often unconscious nature of learning structures is perhaps best illustrated in learning one's native language. Having grasped the subtle structure of a sentence the child very rapidly learns to generate many other sentences based on this model though different in content from the original sentence learned. And having mastered the rules for transforming sentences without altering their meaning--'The dog bit the man' and 'The man was bitten by the dog'--the child is able to vary his sentences much more widely. Yet, while young children are able to use the structural rules of English, they are certainly not able to say what the rules are.³

As this example is of greater complexity than the previous one and the description somewhat confusing, it is deemed necessary to introduce the analysis with a few remarks concerning the text.

The text contains four sentences. The second and third sentences refer to one kind of structure in language; the third sentence refers to a different kind of structure in language. The first and fourth sentences are, respectively, introductory and closing sentences to the examples.

a) The First Structure in the Language Example.- A first example of a structure in language is expressed in the following sentence:

Having grasped the subtle structure of a sentence, the child very rapidly learns to generate many other sentences based on this model though different in content from the original sentence learned.⁴

3 Ibid., p. 8.

4 Ibid., p. 8.

Grammatically speaking, a sentence may be defined as words placed in relationship to convey an intended meaning.

To illustrate the logical conditions of learning the structure of a sentence, the following sentences of identical form are used: the dog bit the man; the gardener mowed the lawn; the carpenter made the table.

One must perceive, on considering the elements of the set of identical sentences, that the referents of the words are irrelevant to the specific relations between the words. That which does (dog, gardener, carpenter) is related to that which is done (bit, mowed, made); that which does and that which is done upon (man, lawn, table) are both related to that which is done.

The child has an un verbalized awareness of the specific relations and their similarity and generalizes (a process) from sets of such specific relations to a set of typical relations i.e. a typical sentence (a generalization as a product).

This network of relations between sentences and a typical sentence constitutes the dynamic component of a structure in language.

The child can now use the typical sentence as a rule to generate other sentences of the same type.

b) The Second Structure in the Language Example.- The third sentence of the text on a structure of language reads:

... and having mastered the rules for transforming sentences without altering their meaning--'The dog bit the man' and 'The man was bitten by the dog'--the child is able to vary his sentences much more widely.⁵

In this second language structure, Bruner shifts to another level. While the first structure, as noted, permits one to generate many other sentences of the same form, the second structure reported in the passage above permits one to vary sentences much more.

The description of the steps taken toward a generalization (as a product) which may be used as a rule is not intended as a description of the developmental process; rather, the description is logical. The child who learns a language cannot describe the rules he applies, much less describe how he learns them. He does, however, in some unconscious way find the rules of transformation.

To analyze the generalization process, sets of sentences of different form are used as basic units: the first set consists of the sentences 'the dog bit the man' and 'the man was bitten by the dog'; the second set consists of the sentences 'the gardener mowed the lawn' and 'the lawn was mowed by the gardener'.

In order not to complicate the explanation more than necessary, it is assumed here that a generalization (product

⁵ Ibid., p. 8.

as a principle) similar to the one in the first part of the example has already been made from particular sentences to a typical sentence so that the elements in the second part of the example are the sentences themselves and not the parts within the sentences.

A step in the generalization process consists of the perception of an identity of meaning within a set of assertive-passive sentences. There is a relation of identity between the meaning of an assertive sentence and the meaning of a passive sentence.

The subjects, verbs, predicates of the sentences must, however, be interrelated in a particular manner if each sentence is to convey the same meaning. In the assertive sentence, the thing which acts upon another (the dog, the gardener) is the subject, the verb (bit, mowed) is active, and the predicate is the thing which is acted upon (the man, the lawn); on the other hand, in a passive sentence, the thing which acts upon another (the dog, the gardener) is the predicate, the verb (was bitten, was mowed) is passive, and the subject is the thing which is acted upon (the man, the lawn).

Thus, in either an assertive or passive sentence, the thing which acts upon another whether subject or predicate is the same (the dog, the gardener), the thing which is acted upon whether subject or predicate is the same (the man,

the lawn), the verb which describes the action is either in the active (in the assertive sentence) or in the passive (in the passive sentence) mood. A specific relation of identity of the referent must be perceived between the subject in an assertive sentence and the predicate in a passive sentence; the same applies to the predicate in an assertive sentence and the subject in a passive sentence.

Finally, the sets of assertive-passive sentences each with its set of specific relations are generalized (as a process) to a typical set of assertive-passive sentences and its set of relations (a generalization as a product).

A set of typical assertive-passive sentences consist, therefore, of two sentences--one assertive, the other passive, whose meanings are identical and in which: 1) the subject which acts on the other in the assertive sentence is related on the basis of identity to the predicate which acts on the other in the passive sentence; 2) the subject which is acted upon in the passive sentence is related on the basis of identity to the predicate which is acted upon in the active sentence; 3) the verb of the assertive sentence is active and the verb of the passive sentence is passive.

This generalization (a product) becomes a transformational rule which may be expressed as follows:

An assertive sentence may be transformed into a passive sentence without altering its meaning on condition

that the subject of the assertive sentence become the predicate of the passive sentence, that the verb be changed to a passive form and that the predicate become the subject. A similar rule could be formulated to change a passive sentence to an assertive sentence.

The network of relations between several sets of assertive-passive sentences and the typical set of assertive-passive sentences constitutes the dynamic component of this kind of structure in language.

The child who has found this rule, be it unconsciously, can now transform sentences without altering their meaning.

C. The Mathematics Example

The following text describes the mathematics example:

... Algebra is a way of arranging knowns and unknowns in equations so that the unknowns are made knowable. The three fundamentals involved in making these equations are commutation, distribution, and association. Once a student grasps the ideas embodied by these three fundamentals, he is in a position to recognize wherein new equations to be solved are not 'new' at all, but variants on a familiar theme.⁶

The text introduces some confusion by changing the object of discourse from rules to transform equations to rules to transform algebraic expressions. The text may be analyzed if it reads as follows: (changes are underlined)

⁶ Ibid., p. 7-8.

Algebra is a way of arranging knowns and unknowns in equations so that the unknowns are made knowable. The three fundamentals in manipulating the algebraic expressions within the equations are commutation, distribution, and association. Once a student grasps the ideas embodied by these three fundamentals, he is in a position to recognize wherein new algebraic expressions to be simplified are not new at all, but variants of algebraic expressions.

The commutative property is used to explain the generalization (as process) but the explanation applies as well to the distributive and associative properties.

The following equations (sets) expressing equivalence between two algebraic expressions are the units used to explain the process: $2 \times 3 = 3 \times 2$, $2 \times 4 = 4 \times 2$, $5 \times 1 = 1 \times 5$. Each member of an equation is a specific algebraic expression.

The process of generalization requires first that each element of a specific algebraic expression within an equation be related to its identical element in the specific algebraic expression on the other side of the equation (e.g. $2 \times 3 = 3 \times 2$); these are the set of specific relations within each equation.

Also, the positions of identical elements in an equation must be perceived as reversed though a relation of equality between algebraic expressions of the equation remains.

The several sets of specific relations characterized by the reversed position of the elements must be generalized (a process) to typical relations between elements on each

side of a typical algebraic expression. But these are minor generalizations.

Through perception of identical relationship between the specific algebraic expressions in several equations (the relationship expressed by the equality sign between $2 \times 3 = 3 \times 2$ is the same as the relationship between $2 \times 4 = 4 \times 2$ and $5 \times 1 = 1 \times 5$) one generalizes to a typical major relationship between two typical algebraic expressions ($a \times b = b \times a$).

The network of relations between the several sets of equivalent specific algebraic expressions and the typical set of equivalent typical algebraic expressions constitutes the dynamic component of a structure in mathematics.

The generalization expressed as the commutative property ($a \times b = b \times a$) can now be used to transform algebraic expressions without changing their content.

3. Interpreted Meaning of a Structure of Knowledge

One observes the commonality of the examples.

First, in each example, there are two levels of knowledge, one level expressing relatively low-level information and the other expressing the transformation of such low-level information into high-level knowledge.

Thus, in the example in biology, we find the tropisms at the low-level and the tropic response at the high-level.

In the example in language, one finds: 1) identical sentences at the low-level and a typical sentence at the high-level; 2) assertive-passive sets of sentences at the low-level and a typical assertive-passive set of sentences at the high-level, the sentences within each set having an identical meaning. In the example in mathematics, one finds sets of specific equivalent algebraic expressions at the low-level and a set of typical equivalent algebraic expressions at the high-level known as the commutative property.

Secondly, at both levels, knowledge acquired and knowledge transformed is expressed in the form of statements: at the first level, the statements are particular; at the high level, the statement is universal.

Each of the two types of statements may be described as a set of entities in relationship. In each statement, whether particular or universal, one finds elements placed in relationship with each other. Thus in a particular statement there are specific elements and specific relations between any two specific elements; in a universal statement, there are typical elements and typical relations between any two typical elements.

Thirdly, the logical requirements of the process by which a typical element is abstracted from specific elements and by which relations are generalized are similar in all examples.

In abstraction, the mind drops the differences between specific elements and produces a class called here typical elements; to put it another way, abstraction eliminates singular qualities and retains only the similar aspects of the specific elements; the typical element expresses 'one nature for many'. For instance, in the example in biology, the mind passes from the many concrete things--inchworms, locusts, beetles, etc.--to a typical element--small organisms, by dropping individual differences between inchworms, locusts, etc. and by retaining what is common--smallness and a life system--such that the typical element 'small organisms' expresses 'inchworms, locusts, etc.'.

The specific relations between specific elements are recognized as identical in all particular statements; they are generalized to typical relations between typical elements in the universal statement. When the generalization of the main specific relation which is expressed by the verb is effected, a structure is constituted.

Objectively, a structure of knowledge therefore implies a network of relations between two levels of knowledge; the two levels of knowledge are its material components while the network of relations is its formal component. Subjectively, a structure of knowledge consists in grasping or understanding or learning the network of relations between the two levels of knowledge.

Throughout the analysis of the examples the term 'generalization' was used to describe either process or a product; it circumvented the difficulty of using Bruner's terminology--grasping, or understanding or learning of structures, principles and ideas. Bruner's terms can now be given an interpreted meaning in the light of the analysis: 'structure' refers to the network of relations between two levels of knowledge; 'grasping', 'understanding', 'learning' refer to generalization as a process; 'idea' possibly refers to generalization as a product; and 'principles' possibly refers to ideas perceived as rules of operation.

4. Sixth Evolving List of Derived Propositions

When one compares the interpreted meaning of structure with the derived propositions of the fifth evolving list one observes:

First, that the proposition 'a fundamental internal structure of knowledge is not only the knowledge of facts, of techniques, etc.' can be retained. The conclusions also confirm 'mutatis mutandis' the sub-proposition that a fundamental internal structure of knowledge implies that high-level knowledge has been sensed behind low-level information and that acquired facts (or information) have been organized or connected in terms of principles and ideas through the process of transformation.

Second, that a structure of knowledge consists in a vast network of relations: specific relations between specific but different elements; specific relations between specific but similar elements; specific relations between sets of specific relations; relations between specific elements and typical elements; relations between specific relations; relations between typical elements; relations between particular and universal statements. Particular and universal statements have been defined as statements whose intended meanings are respectively low-level and high-level knowledge. Analysis of the examples has shown that low-level knowledge may be facts (as in the Biology example) or what might be called elementary principles (as in the second example on language) and that high-level knowledge may be elementary principles (as the tropic response in the Biology example) or high principles (as in the rule for transforming sentences in the second example on language). The important aspect for a structure of knowledge is that relations between the two levels of knowledge be established. Proposition 5 of the fifth evolving list of derived propositions must therefore be revised to take this into account.

Third, some parts of Proposition 6 are confirmed: operations of classification and relationships are performed at low and high levels of knowledge in such a way that the learner attains a view of the world, a representation, which

relates both levels and which can itself be used to operate on its variants.

Fourth, Proposition 4 has to be revised in the light of the interpreted meaning of grasping, or understanding, or learning a structure, principles or ideas; a fundamental internal structure refers to a high level network of relations between two levels of knowledge; a fundamental idea refers to the highest of the two levels of knowledge; a fundamental principle refers to the same fundamental idea used as a rule of operation. The sub-propositions of Proposition 4 should now read: a) a fundamental idea 'in se' or as a rule of operation, i.e. as a fundamental principle, is a constituent part of a fundamental internal structure of knowledge; b) a fundamental idea subsumes a fundamental principle in the sense that it is its logical antecedent; c) attitudes refer to the learner's cognitive set while he is in the process of structuring; d) a fundamental internal structure of knowledge subsumes a fundamental idea and low-level knowledge; e) a fundamental idea as a rule of operation, i.e. as a fundamental principle has wide and powerful applicability and therefore makes non-specific transfer possible.

The other propositions can be retained as such since there is nothing in the conclusions which requires their revision.

One can now formulate the sixth evolving list of derived propositions as follows:

Proposition 1: Same as the fifth evolving list.

Proposition 2: Same as the fifth evolving list.

Proposition 3: Same as the fifth evolving list.

Proposition 4: A fundamental internal structure, fundamental principles, fundamental ideas and attitudes are different but closely related entities.

Specifically,

- a) a fundamental idea by itself, or as a rule of operation i.e. as a fundamental principle is a constituent part of a fundamental internal structure of knowledge;
- b) a fundamental idea subsumes a fundamental principle in the sense that it is its logical antecedent;
- c) attitudes refer to the learner's cognitive set while he is in the process of structuring;
- d) a fundamental internal structure of knowledge subsumes a fundamental idea and low-level knowledge;
- e) a fundamental idea as a rule of operation i.e. as a fundamental principle has wide and powerful applicability and therefore makes non-specific transfer possible.

Proposition 5: A fundamental internal structure of knowledge implies objectively the regular and congruous relations between two levels of knowledge and subjectively, the grasping, or understanding, or learning of these relations. A vast network of relations is implied:

- a) relations amongst the things themselves;
- b) relations amongst facts which express the connectedness of things;
- c) relations between facts and elementary principles (this could be construed as an elementary structure);
- d) relations between facts and a fundamental principle or between an elementary and a fundamental principle (a fundamental structure).

Proposition 6: A fundamental internal structure of knowledge is an internalized symbolic system:

- a) which is the result of operations of classification and relationships;
- b) by means of which the learner represents his view of the world;
- c) and with which he then operates on its variants.

With this incursion into the denotative attributors related to the nature of a fundamental internal structure of knowledge, additional meaning has been acquired. The descriptive attributors, i.e. those that refer to the attributes of a structure of knowledge, will now be analyzed.

CHAPTER VII

THE DESCRIPTIVE ATTRIBUTORS

An examination of the descriptive attributors is required to derive additional explicit propositions concerning a fundamental structure of knowledge.

The author of a communication may wish to convey meaning about some aspects of a pivotal entity that are somewhat connected with it and yet are not part of its essence. To say that 'water is colourless', that 'it freezes at 32° F.' says nothing about the physical or logical components of water but such statements--called descriptive attributors--can convey meaning to the person who reads them in that he now knows that lack of colour is a quality of water and that its state is changed at 32° F.

All types of verbs--linking, transitive and intransitive verbs--are used in descriptive attributors which describe the qualities of a pivotal entity, its modes of action, its relationships to other entities, its effects, its occurrence in time and space, etc. The number of descriptive attributors can be very long; only the most explicit and obvious descriptive attributors are studied in this chapter. In the analysis of attributors the presentation procedure is as follows: an identification of the text(s); short statements summarizing the pertinent points; a discussion if

necessary; finally, a conclusion. A summary and the seventh evolving list of derived propositions follow.

1. Analysis

A. Structure - Comprehensibility

Bruner concludes the chapter on the importance of structure by stating the reasons why the fundamental structure of a subject should be taught. The key words are 'understanding fundamentals' and 'comprehensibility'. He states:

The first [claim] is that UNDERSTANDING FUNDAMENTALS makes a subject more COMPREHENSIBLE [...]. Once one has GRASPED the fundamental IDEA that a nation must trade in order to live, then such a presumably special phenomenon as the Triangular Trade of the American Colonies becomes altogether SIMPLER TO UNDERSTAND as something more than commerce in molasses, sugar cane, rum and slaves in an atmosphere of violation of British trade regulations. The high school student reading Moby Dick can only UNDERSTAND more deeply if he can be led to understand that Melville's novel is, among other things, a study of the THEME of evil and the plight of those pursuing this 'killing whale'. And if the student is led further to UNDERSTAND that there are a relatively limited number of human plights about which novels are written, he UNDERSTANDS literature the better for it.¹

The gist of this text is expressed in the first sentence: understanding fundamentals makes a subject more comprehensible; what follows this statement is an explanation.

¹ Jerome S. Bruner, The Process of Education, Cambridge, Harvard University Press, 1960, p. 23-24.

It is obvious from the context that Bruner wishes to lay a claim for teaching the structure of a subject. And yet, in the above text, there is no mention of structure. The term 'fundamentals' is ambiguous, though there are two referents in the text itself--ideas and themes. However, what is described as a fundamental idea in the social studies example contains at least three concepts 'nations', 'trade', 'living' in relation to each other. One concludes that a fundamental idea is one to which specifics have been related and to which other things may be related.

The fundamental idea that 'a nation must trade in order to live' is reached through recognition that there is a relation between the many facts and observations (molasses was transported to American Colonies; some American goods were exchanged; this commerce was in violation of British Trade regulations) and the concepts of nation and living. The knowledge of the fundamental idea makes other things, such as the East-West struggle, "simpler to understand". The same could be said of the literature example. But a fundamental idea is a constituent part of the network of relations between two levels of knowledge--a structure.

One can therefore conclude that a fundamental internal structure of knowledge makes other things related to it comprehensible, i.e. it makes other things understandable in terms of relationships.

There are two main attributors by means of which Bruner conveys the idea that structure and memory are linked.

The first text is taken from Bruner's list of claims for teaching the structure of a subject; the correlative is of course the learning of structures. He states:

The second point relates to human MEMORY. Perhaps the most basic thing that can be said about human memory, after a century of intensive research, is that unless detail is placed into a STRUCTURED PATTERN, it is rapidly forgotten. Detailed material is conserved in memory by the use of simplified ways of representing it. These SIMPLIFIED REPRESENTATIONS have what may be called a 'regenerative character'. A good example of this regenerative property of long-term memory can be found in science. A scientist does not try to remember the distances traversed by falling bodies in different gravitational fields over different periods of time. What he carries in MEMORY instead is a formula that permits him with varying degrees of accuracy to regenerate the details on which the more easily remembered formula is based [...] We remember a FORMULA, a VIVID DETAIL that carries the meaning of an event, an AVERAGE that stands for a range of events, a CARICATURE, or PICTURE that preserves an essence--all of them techniques of condensation and REPRESENTATION. What learning general or fundamental principles does is to ensure that memory loss will not mean total loss, that what remains will permit us to reconstruct the details when needed...²

The second text was intended as a recapitulation of the first. Bruner states:

² Ibid., p. 24-25.

... knowledge one has acquired without sufficient STRUCTURE to tie it together is knowledge that is likely to be forgotten. An UNCONNECTED SET OF FACTS has a pitifully short half-life in MEMORY. Organizing facts in terms of PRINCIPLES AND IDEAS from which they may be inferred is the only known way of reducing the quick rate of loss of human memory.³

The above texts may be summarized in the following statements: details must be placed into a structure or structured pattern if they are not to be forgotten; simplified representations conserve details in memory; a formula, a vivid detail, an average, a caricature, a picture are simplified representations; the learning of fundamental principles ensures the longer retention of some details and the possibility of reconstructing them.

To make clear the connection between structure and representations the two texts are studied in relation to two others. The first is from Bruner's description of the act of learning.

A second aspect of learning may be called transformation--the process of manipulating knowledge to make it fit new tasks. We learn to 'unmask' or analyze information, to order it in a way that permits extrapolation or interpolation or CONVERSION INTO ANOTHER FORM...⁴

The second text is from Bruner's discussion on concrete operations:

3 Ibid., p. 31-32.

4 Ibid., p. 48.

... Such internal structures are of the essence.
They are the internalized symbolic systems by which
the child REPRESENTS the world,...⁵

Internal structures are therefore representations which may be more or less complex. The complex representations can be further transformed by converting them or condensing them into formulae, caricatures or pictures that preserve their essence. Techniques of condensation and representation are means of connecting information which has been analyzed and ordered. It is in the sense of this double transformation that learning structures helps memory, though Bruner does not specifically mention it.

The relationship between fundamental structures, fundamental principles and fundamental ideas has already been discussed. As a result of that discussion and explanations which have been incorporated into the evolving list of derived propositions, the conclusion was drawn that structure subsumes principles and ideas. Memory is therefore aided directly through the learning of fundamental ideas but since they are a constituent part of a fundamental internal structure, one can conclude that a fundamental internal structure of knowledge aids memory, i.e. it does not overload the memory capacities and permits reconstruction of the details.

⁵ Ibid., p. 37.

C. Structure - Transfer

Attributors concerning the relationship of structure to transfer recur several times in The Process of Education. In fact, it could constitute a theme to which all other attributors might be related.

Third, an understanding of fundamental PRINCIPLES AND IDEAS, as noted earlier, appears to be the main road to adequate 'transfer of training'. To understand something as a specific instance of a more general case--which is what understanding a more fundamental PRINCIPLE OR STRUCTURE means--is to have learned not only a specific thing but also a MODEL for understanding other things like it one may encounter. If a student grasps in its most human sense the weariness of Europe at the close of the Hundred Years' War and how it created the conditions for a workable but not ideologically absolute Treaty of Westphalia, he might be better able to think about the ideological struggle of East and West--though the parallel is anything but exact. A carefully wrought understanding should also permit him to recognize the limits of the GENERALIZATION as well. The idea of 'PRINCIPLES, and 'CONCEPTS' as a basis for TRANSFER is hardly new.⁶

On "the role of structure in learning and how it may be made central in teaching", he declares:

... The teaching and learning of STRUCTURE, rather than simply the mastery of FACTS AND TECHNIQUES, is at the center of the classic problem of TRANSFER. There are many things that go into learning of this kind, not the least of which are SUPPORTING HABITS AND SKILLS that make possible the active use of the materials one has come to understand. If earlier learning is to render later learning easier, it must do so by providing a GENERAL PICTURE in terms of which the relations between things encountered earlier and later are made as clear as possible.⁷

6 Ibid., p. 25.

7 Ibid., p. 12.

Finally, more directly, on the nature of transfer of principles and attitudes, Bruner stated:

In essence, it [the transfer of PRINCIPLES AND ATTITUDES] consists of learning initially not a skill but a GENERAL IDEA, which can then be used as a basis for recognizing subsequent problems as special cases of the idea originally mastered.⁸

The following statements are extracted from the above texts: fundamental principles and ideas permit non-specific transfer; a learned principle or structure is a model for understanding other things like it one may encounter; the learning of structure with its supporting habits and skills makes possible the active use of materials one has come to understand; a general picture in which relations between things are clear renders later learning easier; a general idea permits recognition of subsequent problems as special cases of it.

Following up on the conclusions already reached concerning the relationship among fundamental structure, fundamental ideas, fundamental principles, general picture, and keeping in mind the distinctions between these entities, one can state that 'fundamental structure' is part of the subject phrase in each of the above summary statements. Also, the verb-phrase 'permits non-specific transfer' can be substituted for the verb phrase in each of the statements.

⁸ Ibid., p. 17.

One must recall, at this point, Bruner's distinction between two types of transfer: specific and non-specific. In pointing to a historical shift in interest of the psychologists of the learning process, Bruner states:

It is interesting that around the turn of the last century the conception of the learning process as depicted by psychology gradually shifted away from an emphasis upon the production of general understanding to an emphasis on the acquisition of specific skills. The study of 'transfer' provides the type case--the problem of the GAIN IN MASTERY of other activities that one achieves from having mastered a particular learning task. Whereas the earlier emphasis had led to research studies on the TRANSFER OF FORMAL DISCIPLINE--the value obtained from the training of such 'faculties' as ANALYSIS, JUDGMENT, MEMORY, and so forth--later work tended to explore the transfer of identical elements or specific skills [...] Virtually all of the evidence of the last two decades on the nature of learning and transfer has indicated that, while the original theory of formal discipline was poorly stated in terms of the training of faculties, it is indeed a fact that massive GENERAL TRANSFER can be achieved by appropriate learning, even to the degree that learning properly under optimum conditions leads one 'TO LEARN HOW TO LEARN'.⁹

If the mastery of particular learnings leads to a gain in mastery of other activities, mastery of the structure of subject matter which emphasizes general understanding should lead to a greater gain in the mastery of activities of an intellectual nature such that a person will 'be able to recognize the applicability or inapplicability of an idea to

⁹ Ibid., p. 5-6.

a new situation and to broaden his learning thereby'.¹⁰ In other words, it should lead to general transfer.

A conclusion can now be drawn in the form of a statement: a fundamental structure of knowledge developed from the fundamental structure of a subject enables one to achieve general transfer, i.e. to recognize subsequent problems as special cases of the ideas originally mastered.

D. Structure - Continuity of Knowledge

Some attributors manifest the intent of the author to relate structure to continuity of knowledge as in the first sentence of the following text:

The fourth claim for emphasis on STRUCTURE AND PRINCIPLES in teaching is that by constantly reexamining material taught in elementary and secondary schools for its fundamental character, one is able to narrow the gap between 'advanced' knowledge and 'elementary' knowledge. Part of the difficulty now found in the progression from primary school through high school to college is that material learned earlier is either out of date or misleading by virtue of its lagging too far behind developments in a field.¹¹

In a recapitulation of the claims for teaching a fundamental structure Bruner states:

... The best way to create interest in a subject is to render it worth knowing, which means to make the knowledge gained usable in one's thinking beyond the situation in which the learning has occurred...¹²

10 Ibid., p. 18.

11 Ibid., p. 25-26.

12 Ibid., p. 31.

The above paragraphs are summarized in the following statements: teaching fundamental structure and fundamental principles narrows the gap between elementary and advanced knowledge; knowledge gained must be such that it is usable in one's thinking.

There is no contradiction in the use of the terms principles and structure in the above statements if one keeps in mind the conclusion already reached concerning the relationship between structure and principles, i.e. principles are subsumed under structure.

Concerned with the obsolescence and the quality of much that is learned, Bruner claims that teaching a fundamental structure helps to bridge the gap between obsolete and expanding knowledge, between elementary and advanced knowledge; indirectly, he is stating that learning the fundamental structure of a subject is a stepping-stone to more broad and deep knowledge.¹³ The child does not represent a fundamental structure at the outset in the same way that a scholar does. Indeed the mode of representation is according to the child's way of viewing things.¹⁴ The first representations can be made more powerful and precise; it is in that context that Bruner states his hypothesis "that any subject

13 Ibid., p. 17.

14 Ibid., p. 34.

can be taught effectively in some intellectually honest form to any child at any stage of development".¹⁵

One can therefore conclude that a fundamental internal structure of knowledge provides for continuity in the expansion and deepening of one's knowledge, i.e. it constitutes a stepping stone to go beyond. In that sense, it serves in the future.¹⁶

E. Structure - Simplicity and Power

In reference to the proposition that the foundations of any subject may be taught to anybody at any age in some form, Bruner manifests his intent to link structure, simplicity and power. He writes:

... its intent is to underscore an essential point often overlooked in the planning of curricula. It is that the BASIC IDEAS that lie at the heart of all science and mathematics and the basic THEMES that give form to life and literature are as SIMPLE as they are POWERFUL...¹⁷

The following text emphasizes some aspects of the above:

15 Ibid., p. 33.

16 Ibid., p. 17.

17 Ibid., p. 12-13.

... The more FUNDAMENTAL OR BASIC is the IDEA he has learned, almost by definition, the greater will be its breadth of applicability to new problems. Indeed, this is almost a tautology, for what is meant by 'fundamental' in this sense is precisely that an idea has wide as well as POWERFUL applicability.¹⁸

The following texts are in the same vein:

The first and most obvious problem is how to construct curricula that can be taught by ordinary teachers to ordinary students and that at the same time reflect clearly the BASIC OR UNDERLYING PRINCIPLES of various fields of inquiry. The problem is twofold: first, how to have the basic subjects rewritten and their teaching materials revamped in such a way that the pervading and POWERFUL IDEAS and attitudes relating to them are given a central role...¹⁹

... The general hypothesis that has just been stated [that any subject can be taught effectively in some intellectually honest form to any child at any stage of development] is premised on the considered judgment that any idea can be represented honestly and usefully in the thought forms of children of school age, and that these first representations can later be made more POWERFUL and precise the more easily by virtue of this early learning...²⁰

The above texts are summarized in the following statements: basic ideas and basic themes are simple and powerful; a basic idea has powerful applicability; first representations of children can later be made more powerful.

If, as it has been concluded, basic ideas are constituent elements of a fundamental internal structure of knowledge

18 Ibid., p. 18.

19 Ibid., p. 18.

20 Ibid., p. 33.

and if what affects a constituent part affects the whole, then one can say that what is said about basic ideas applies as well to a fundamental structure. Moreover, Bruner applies the term representation²¹ to ideas and to structures as evidenced in the phrases "any idea can be represented",²² "internal structures [...] by which the child represents the world".^{23,24} One can therefore conclude that the subject-phrase in the above statement can be changed to 'a fundamental structure of knowledge'. The term powerful refers to the quality of effective applicability of basic ideas and representations to problems and situations; the term simple refers to the proposition that they are free of details.

One can therefore conclude that a fundamental internal structure of knowledge is simple and powerful; simple because the fundamental ideas which are a constituent part of structure are free of complex details; powerful because as rules of operations, i.e. as principles, fundamental ideas have the quality of effective applicability to problems and situations.

21 Ibid., p. 24.

22 Ibid., p. 33.

23 Ibid., p. 37.

24 Ibid., p. 32.

F. Structure - Effectiveness

Some descriptive attributors manifest the intent of the author to convey to the reader a relationship between structure and the manner it increases the intellectual powers of the person who has developed it.

The text which follows is taken from Bruner's discussion of the concrete operational stage:

With the advent of concrete operations, the child develops an internalized structure with which TO OPERATE. In the example of the balance scale, the structure is a serial order of weights that the child has in his mind...²⁵

An internalized structure is therefore a means to operate in the sense that one uses it to deal with a problem of a similar nature; thus the serial order of weights--a structure--once grasped, can be used to solve another problem involving the balancing of weights.

The focus here is on the person who operates by means of a structure of knowledge.

The following texts, all taken from Bruner's chapter on intuitive and analytic thinking, also emphasize the effective use that a person makes of a structure of knowledge.

²⁵ Ibid., p. 36.

... Yet we can distinguish between inarticulate genius and articulate idiocy--the first represented by the student who, BY HIS OPERATIONS AND CONCLUSIONS, reveals a deep grasp of a subject but not much ability to 'say how it goes', in contrast to the student who is full of seemingly appropriate words but has no matching ability to use the ideas for which the words presumably stand...²⁶

... Certainly there are some experiments on learning that indicate the importance of a high degree of mastery of materials in order TO OPERATE effectively with them intuitively.²⁷

In this connection we may ask whether, in teaching, emphasis upon the structure or connectedness of knowledge increases facility in intuitive thinking. Those concerned with the improvement of the teaching of mathematics often emphasize the importance of developing in the student an understanding of the structure or order of mathematics. The same is true for physics. Implicit in this emphasis, it appears, is the belief that such understanding of structure enables the student, among other things, TO INCREASE HIS EFFECTIVENESS in dealing intuitively with problems.²⁸

The following short statements summarize the pertinent points: the operations one uses and the conclusions one reaches reveal the grasp one has of a subject; a high degree of mastery of materials enables one to operate effectively with them intuitively; it is believed that an understanding of structure enables one to increase one's effectiveness in dealing intuitively with problems.

The emphasis in each of the above statements is on a person's increased effectiveness when that person has developed

26 Ibid., p. 55.

27 Ibid., p. 57.

28 Ibid., p. 62-63.

an internal structure of knowledge. The last of the above summarizing statements weakens this conclusion, though one must be aware that Bruner is reporting an opinion; his position regarding effectiveness is stronger as evident in the following text. He writes:

... Individuals who have extensive familiarity with a subject appear more often to leap intuitively into a decision or to a solution of a problem--one which later proves to be appropriate. The specialist in internal medicine, for example, may, upon seeing a patient for the first time, ask a few questions, examine the patient briefly, and then make an accurate diagnosis [...] Perhaps under these circumstances intuition consists in USING A LIMITED SET OF CUES, because the thinker KNOWS WHAT THINGS ARE STRUCTURALLY RELATED TO WHAT OTHER THINGS...²⁹

Thus, at least in intuitive thinking, the person who has developed an internal structure of knowledge in such a way that he is very familiar with it³⁰ can operate quickly³¹ and with facility³² in dealing with problems. It is in that sense that an internal structure of knowledge is effective.

But is it the case also for analytic thinking? In The Process of Education, Bruner wished to emphasize the importance of intuitive thinking and does not discuss analytic thinking to any great extent except in contrast to intuitive

29 Ibid., p. 62.

30 Ibid., p. 58.

31 Ibid., p. 58.

32 Ibid., p. 62.

thinking. However, the following text provides a partial answer to the question above. He states:

... It is certainly clear that it is important not to confuse intuitive and other kinds of thinking with such evaluative notions as EFFECTIVENESS AND INEFFECTIVENESS: THE ANALYTIC, THE INDUCTIVE, AND THE INTUITIVE CAN BE EITHER...³³

One can conclude from this statement that analytic thinking can also be effective. One would have to assume though that the same conditions prevail as for intuitive thinking, namely, possession of an internal structure of knowledge and extensive familiarity with it.

From this analysis of the attributors bearing on effectiveness, one can therefore conclude that an internal structure of knowledge, on condition that one be familiar with it, enables a person to operate effectively in dealing with problems, whether the mode of thought is intuitive or analytic, i.e. it is effective whether one operates quickly and with facility as in intuitive thinking or more systematically and formally as in analytical thinking.

G. Structure - Embodiment

Some attributors manifest the intent to relate a structure of knowledge to its embodiment in various more or less concrete forms.

³³ Ibid., p. 59.

In connection with the conservation of detailed material in human memory, Bruner stated:

... unless detail is placed into a structural pattern, it is rapidly forgotten. Detailed material is conserved in memory by the use of simplified ways of representing it. [...] We remember a FORMULA, a VIVID DETAIL that carries the meaning of an event, an AVERAGE that stands for a range of events, a CARICATURE or PICTURE that preserves an essence--all of them techniques of condensation and representation...³⁴

The last chapter of The Process of Education discusses what Bruner calls a conjecture--"how best to aid the teacher in the task of instruction".³⁵ Concerning model devices, he states:

A second type of teaching aid has the function of helping the student to grasp the UNDERLYING STRUCTURE of a phenomenon--to sense the genotype behind the phenotype, [...] The well wrought laboratory experiment or demonstration is the classic aid in such activity [...] The effort to give visible EMBODIMENT to ideas in mathematics is of the same order as the laboratory work [...] Needless to say, films and television as well as adroitly illustrated books can be adjuncts to the effort at producing clarity and concrete EMBODIMENT.³⁶

The following short statements are derived from the above texts: detailed material placed into a structured pattern is conserved in memory through simplified representations such as a formula, a vivid detail etc.; model devices

³⁴ Ibid., p. 24-25.

³⁵ Ibid., p. 16.

³⁶ Ibid., p. 81-82.

which embody ideas help students to grasp the underlying structure of a phenomenon.

A distinction is implied here between the structure of a phenomenon and a structure of knowledge; the first is external to the person while the second is internal to him. A structure of knowledge requires the activity of the subject in the grasping of relationships. While there is some correspondence between the two, the structure of a phenomenon cannot be apprehended unless the subject is active.

The conclusion remains, however, that a structure of knowledge can be represented externally or embodied either symbolically as in a formula or concretely as in a model device.

H. Structure - Economy

Some attributors may manifest the author's intent to convey to the reader how the learning of structures compares to other types of learning by appealing to the reader's desire for effectiveness.

The text which reflects that intent comes at the end of the chapter on The Importance of Structure; it is an attempt to restate the reasons why fundamental structures should be taught and learned. Bruner states:

To recapitulate, the main theme of this chapter has been that the curriculum of a subject should be determined by the most fundamental understanding that can be achieved of the underlying principles that give STRUCTURE to that subject. Teaching SPECIFIC TOPICS OR SKILLS without making clear their context in the broader FUNDAMENTAL STRUCTURE of a field of knowledge is UNECONOMICAL in several deep senses. In the first place, such teaching makes it exceedingly difficult for the student to GENERALIZE from what he has learned to what he will encounter later. In the second place, learning that has fallen short of a grasp of general principles has little REWARD in terms of intellectual excitement. The best way to create interest in a subject is to render it worth knowing, which means to make the knowledge gained usable in one's thinking beyond the situation in which the learning has occurred. Third, knowledge one has acquired without sufficient STRUCTURE to tie it together is knowledge that is likely to be forgotten. An unconnected set of facts has a pitifully short half-life in MEMORY. Organizing facts in terms of principles and ideas from which they may be inferred is the only known way of reducing the quick rate of loss of human memory.³⁷

To paraphrase Bruner's text, understanding achieved in the broader context of the underlying principles that give structure to a subject is more economical than the learning of specific topics and skills because: a) the learner can generalize from this structure to other things he encounters; b) the learner can use it to go beyond the situation in which learning has occurred; c) the learner can retain acquired knowledge longer.

One can conclude that economy is a general attribute of a fundamental internal structure in that it is a consequence

³⁷ Ibid., p. 31-32.

of several of the other attributes discussed in the preceding pages; through the learning of structure, general transfer, continuity and deepening of one's knowledge, and retention are easier than through the learning of specific topics and skills.

2. Seventh evolving list of derived propositions

The conclusions reached from an analysis of the descriptive attributors of a fundamental internal structure of knowledge may be regrouped as follows. A fundamental internal structure of knowledge:

- 1^o makes other things related to it comprehensible, i.e. it makes other things understandable in terms of relationships;
- 2^o enables one to achieve general transfer, i.e. to recognize subsequent problems as special cases of the ideas originally mastered;
- 3^o aids memory, i.e. it does not overload the memory capacities and permits the reconstruction of details;
- 4^o provides for continuity in the expansion and deepening of one's knowledge, i.e. it constitutes a stepping stone to go beyond.
- 5^o is simple, i.e. it is free of complex details;
- 6^o is powerful, i.e. it has the quality of effective applicability to problems and situations;
- 7^o is effective whether the mode of thought is intuitive or analytic; intuitively as when one operates quickly and with facility, analytically as when one operates more systematically and formally;
- 8^o can be represented externally or embodied either symbolically as in a formula or concretely as in a model device;

- 9⁰ is economical, i.e. through the learning of structure, general transfer, continuity and deepening of knowledge and retention are easier than through the learning of specific topics and skills.

A comparison of the above conclusions with the derived propositions of the sixth evolving list shows their similarity. Some conclusions refer to the usefulness of a fundamental internal structure of knowledge; comprehensibility, general transfer, aid to memory, continuity in the expansion and deepening of one's knowledge. The sub-propositions of Proposition 3 also refer in just about the same terms to the usefulness of a fundamental internal structure of knowledge: sub-proposition b) of Proposition 3 refers to comprehensibility; sub-proposition a) refers to general transfer; sub-proposition d) refers to memory; and sub-proposition c) refers to the continuity and deepening of one's knowledge.

The conclusion concerning a structure's economy is stated as a separate proposition of the seventh evolving list because it is as a consequence of its usefulness as compared with specific topics and skills that a structure is economical.

Other conclusions more immediately relate to a structure's inherent qualities than to its usefulness. If one looks at a fundamental internal structure as a form of knowledge, it is simple, powerful, effective and representable; it is because of these qualities that the learner can use it as a means to understand other things, to expand and deepen

one's knowledge, etc. These attributes are grouped in Proposition 8.

The other propositions of the sixth evolving list are unaffected by the conclusions reached in this chapter.

The seventh evolving list of derived propositions can now be stated as follows:

Proposition 1: Same as in the fifth and sixth evolving list.

Proposition 2: Same as in the fifth and sixth evolving list.

Proposition 3: A fundamental internal structure of knowledge is useful in:

- a) achieving general transfer, i.e. in recognizing because of its breadth of applicability:
 - that relations between things one encounters now are the same kind of relations between things one encountered earlier;
 - that something is a specific instance of a more general case;
- b) comprehending other things, i.e. it makes other things understandable;
- c) providing for continuity in the expansion and deepening of one's knowledge, that is, other things can be generated from structure, i.e. other observable characteristics effects, etc. can be hypothesized;

- d) retaining what has been understood, i.e. it does not overload the memory capacities and permits reconstruction of details.

Proposition 4: Same as in the sixth evolving list.

Proposition 5: Same as in the sixth evolving list.

Proposition 6: Same as in the sixth evolving list.

Proposition 7: A fundamental internal structure of knowledge as a consequence of its usefulness (general transfer, continuity, retention) is more economical than the knowledge of specific topics and skills.

Proposition 8: A fundamental internal structure of knowledge is

- a) comprehensible, i.e. it makes other things understandable in terms of relations;
- b) simple, i.e. it is free of complex details;
- c) powerful, i.e. it has the quality of effective applicability to problems and situations;
- d) effective, whether the mode of thought is intuitive or analytic; intuitively as when one operates quickly and with facility; analytically as when one operates more systematically and formally;
- e) representable, i.e. it can be embodied in a symbolic mode as in a formula or in a concrete mode as in a model device.

In the next two chapters the causal attributors of a fundamental internal structure of knowledge are analyzed to determine the factors that bring it about.

CHAPTER VIII

THE AGENTIVE ATTRIBUTORS

The analysis of the attributors in the preceding chapters focussed on the nature and attributes of a structure of knowledge, but there are other types of attributors by means of which the author of a communication wishes to convey something about the extrinsic factors upon which a fundamental internal structure of knowledge depends. There are agentive attributors which convey something about the action of agents as effectors of structure and there are purposive attributors which convey something about the intentions, the motives of the human agents.

The purposive attributors are analyzed in Chapter IX. This chapter purports to analyze and discuss the agentive attributors; some refer to the learner as the principal effector, others refer to effectors which have an assistance value to the learner. Those which refer to the learner have been grouped under three main headings: the process (developmental and learning), the modal and the conditional attributors. The attributors which refer to effectors which have an assistance value have been called instrumental attributors. The procedure for the analysis is the same as that followed in the other chapters. The eighth evolving list of derived propositions incorporates the conclusions.

1. Analysis

A. The Process Attributors

The intent of the author in the use of process attributors of a structure of knowledge is to indicate what happens when one is learning it. They are often recognizable in sentences and in collections of related sentences. A sentence in which the subject is the agent, the verb a causative transitive verb (e.g. produces, brings about) and the object the pivotal entity, is a process attributor; a sentence in which abstract process nouns (such as formation, development) are used, also points to a process attributor. Sentences, sometimes widely scattered through a publication, in which either the agentive noun phrases or the causative verb phrases are common (such as in the two sentences 'Light rays from the sun produce heat' and 'A surface which reflects light rays produces heat') are also classified as "process" attributors.

The attributors one is seeking in this section are those which refer to the internal factors. Wherever possible, attributors in the form of a sentence are considered for analysis in preference to attributors in the form of a collection of sentences.

Bruner concludes the chapter on the importance of structure with the following paragraph:

How may the kind of curriculum we have been discussing be brought within the intellectual reach of children of different ages? To this problem we turn next.¹

The curriculum to which he refers is one which "reflects the basic structure of a field of knowledge".² The above transition paragraph and the first paragraph of the chapter on readiness for learning signal Bruner's intent to show how the structure of any subject can be taught to anybody at any age in some form.³ This hypothesis is supported by three specific argumentations related to the course of intellectual development, the act of learning and the notion of spiral curriculum; only the attributors found in the first two are studied in this section.

a) The Developmental Process Attributors.- Bruner devotes several pages in The Process of Education to the course of intellectual development with the purpose of establishing the plausibility of the hypothesis "that any subject can be taught effectively in some intellectually honest form to any child at any stage of development"⁴ provided we represent "the structure of that subject in terms of the

1 Jerome S. Bruner, The Process of Education, Cambridge, Harvard University Press, 1960, p. 32.

2 Ibid.

3 Ibid., p. 12, 33, 52.

4 Ibid., p. 33.

child's way of viewing things".⁵

The developmental attributors, i.e. those that indicate how children of various ages develop structures, are found in sentences in which a structure of knowledge or some cognate term is explicitly or implicitly the logical subject and the accompanying phrases--a verb phrase or a prepositional phrase (e.g. by means of)--imply causation or process.

One can find few explicit developmental attributors of a structure of knowledge in Bruner's discussion of intellectual development though many are implied from the context and from analysis of the text.

Bruner, with Piaget, distinguishes three stages in the intellectual development of the child: the preoperational, the concrete operational and the formal operational stage. In his description of the second stage, Bruner states:

⁵ Ibid., p. 33.

With the advent of CONCRETE OPERATIONS, the child develops an internalized STRUCTURE with which to operate. In the example of the balance scale, the STRUCTURE is a serial order of weights that the child has in his mind. Such INTERNAL STRUCTURES are of the essence. They are the internalized symbolic systems by which the child represents the world, as in the example of the pinball machine and the angles of incidence and reflection. It is into the language of these INTERNAL STRUCTURES that one must translate ideas if the child is to grasp them.

But CONCRETE OPERATIONS, though they are guided by the LOGIC OF CLASSES and the LOGIC OF RELATIONS, ARE MEANS FOR STRUCTURING only immediately present reality. The child is able to give STRUCTURE to the things he encounters, but he is not yet readily able to deal with possibilities not directly before him or not already experienced. This is not to say that children OPERATING concretely are not able to anticipate things that are not present. Rather, it is that they do not command the OPERATIONS for conjuring up systematically the full range of alternative possibilities that could exist at any given time.⁶

The text may be summarized as follows: concrete operations are the means by which internal structures of present reality are developed; concrete operations are guided by the logic of classes and the logic of relations; internal structures are the internalized symbolic systems by which the child represents the world (e.g. the serial order of weights that represent the balancing of a scale); the child at the concrete operational stage uses but does not command the operations by means of which internal structures are developed; internal structures at the concrete operational level have a language of their own into which ideas must be

6 Ibid., p. 36-37.

translated.

At the concrete operational stage then, the child develops internal structures of present reality by means of concrete operations; Bruner's text is clear on this point. But what of the pre-operational and formal operational stages? Clear attributors for these stages are non-existent. Before drawing more general conclusions from the above statements, it is deemed necessary to determine more precisely the products of operations at different age levels. Bruner's explanation of the nature of operations and their characteristics constitutes the background for this analysis.

1) The nature of operations.- Bruner describes an operation as follows:

... An OPERATION is a type of action: it can be carried out rather directly by the MANIPULATION OF OBJECTS, or internally, as when one MANIPULATES SYMBOLS that REPRESENT THINGS AND RELATIONS in one's mind. Roughly, an OPERATION is a means of getting DATA about the real world into the mind and there TRANSFORMING them so that they can be ORGANIZED and USED selectively in the solution of problems...⁷

One's comprehension of an operation is not helped to any great extent by the above description. To say that an operation is a type of action is much too vague; the remaining part of the text deals with the levels of operation and their effects rather than with an operation 'per se'. Still,

⁷ Ibid., p. 35.

there are some key terms, that could help one understand what is meant by an operation and its relation to structure, terms such as manipulation, representation, transformation, organization, utilization.

The first sentence of the last quoted text specifies the possible objects of operations: the things themselves or the symbols that represent things and symbols. Operations are used: to manipulate objects and symbols (which represent things and relations) in order to acquire data; to transform the data into an organized whole; to transform the data selectively.

If the two texts quoted in this section are compared, one observes that the term 'means' is used in both to define an operation though in one case Bruner is defining concrete operations while in the other an operation in general: "concrete operations [...] are the means for...", "an operation is a means of...". A further distinction is made in terms of the prepositional phrases which follow the terms 'means': the statement "concrete operations [...] are the means for structuring only immediately present reality" expresses the task which concrete operations accomplish; the statement "an operation is a means of getting data about the real world into the mind and there transforming them so that they can be organized and used selectively in the solution of problems" expresses a process which culminates in the

organization of data and its consequent utilization in the solution of problems. The connection between these two statements is obvious: Structuring implies the process of acquiring data and of transforming them into organized wholes by means of operations.

2) The characteristics of an operation.- Bruner points to some differences between operation and action in the following text:

An operation differs from simple action or goal-directed behavior in that it is INTERNALIZED and REVERSIBLE. 'Internalized' means that the child does not have to go about his problem-solving any longer by overt trial and error, but can actually carry out TRIAL AND ERROR IN HIS HEAD. Reversibility is present because operations are seen as characterized where appropriate by what is called 'complete COMPENSATION'; that is to say, an operation can be compensated for by an inverse operation...⁸

Thus in the manipulation of objects and symbols, problem-solving can be carried out by means of internalized and reversible operations such as disjunction, combination,⁹ addition, multiplication, inclusion, ordering,¹⁰ transitivity,¹¹ etc. which yield internalized structures, i.e. symbolic systems by which the world is represented.¹²

8 Ibid., p. 36.

9 Ibid., p. 45.

10 Ibid., p. 46.

11 Ibid., p. 42.

12 Ibid., p. 36.

3) The products of operations at different age levels.- Bruner illustrates the effects of operations at different age levels by means of an example,¹³ which is summarized as follows: Children of different ages appreciate in a different way the relation between the angle of incidence and the angle of reflection as exemplified in the pinball machine. The young child views it as a ball that travels in an arc touching the wall on the way; the child of ten views the angles as roughly related in the sense that if one changes so does the other; the still older child begins to see a fixed relationship between the two angles usually in terms of a right angle triangle; finally the thirteen or fourteen-year old views the two angles as equal. And Bruner concludes:

... Each way of looking at the phenomenon REPRESENTS THE RESULT OF AN OPERATION in this sense, and the child's thinking is constrained by his way of pulling his observations together.¹⁴

The children are dealing with the same kind of phenomenon; yet, the young child's way of viewing the relationship is largely perceptual while the older children come to view the true relationship between the two angles gradually--from a rough relationship to a fixed relationship and thence to the equality of the two angles. Each way of viewing the relationship--a representation--is the result of an operation.

13 Ibid., p. 35-36.

14 Ibid., p. 36.

Bruner links representation and structure by stating that structures "are the internalized symbolic systems by which the child represents the world, as in the example of the pinball machine".¹⁵ It is important to note, however, that these representations are symbolic.

This suggests that the very young child--the preoperational child--though he develops representations, does not develop structures, at least not fundamental structures. This seems to be confirmed by the fact that the term structure does not appear in Bruner's discussion of this stage. He describes this stage thusly:

... In this stage, which ends (at least for Swiss school children) around the fifth or sixth year, the child's mental work CONSISTS PRINCIPALLY IN ESTABLISHING RELATIONSHIPS BETWEEN EXPERIENCE AND ACTION; his concern is with manipulating the world through action. This stage corresponds roughly to the period from the first development of language to the point at which the child learns to manipulate symbols. In this so-called pre-operational stage, the principal symbolic achievement is that the child LEARNS HOW TO REPRESENT THE EXTERNAL WORLD THROUGH SYMBOLS ESTABLISHED BY SIMPLE GENERALIZATION; things are represented as equivalent in terms of sharing some common property. But the child's symbolic world does not make a clear separation between internal motives and feelings on the one hand and external reality on the other. The sun moves because God pushes it, and the stars, like himself, have to go to bed. The child is little able to separate his own goals from the means of achieving them, and when he has to make corrections in his activity after unsuccessful attempts at manipulating reality, he does so by what are called INTUITIVE REGULATIONS RATHER THAN BY SYMBOLIC OPERATIONS, the former being of a crude trial-and-error nature rather than the result of taking thought.¹⁶

15 Ibid., p. 37.

16 Ibid., p. 34.

It appears at this stage that the child possesses nothing more, at best, than the rudiments of a structure of knowledge. If operations are guided by the logic of classes and the logic of relations,¹⁷ the pre-operational child does not seem to be so guided; he manipulates reality through action and corrects his manipulations through intuitive regulations, i.e. by concrete trial-and-error rather than by symbolic operations (trial-and-error in his head); his generalizations are simple and discrete; his connections are based on his internal motives and feelings; he focusses on one feature of a phenomenon rather than attending to several at once; he manipulates objects through action not through operations; he represents the world through symbols but is not able to manipulate the symbols; he collects observations but cannot pull his observations together by means of an operation;¹⁸ he transforms objects but cannot restore them to their original form.

In view of these major differences between the pre-operational stage and the other stages, one cannot say that, according to Bruner, the pre-operational child possesses a fundamental structure of knowledge though he has a way of representing the world. In a fundamental structure of

17 Ibid., p. 37.

18 Ibid., p. 36.

knowledge the representation has the characteristic of a system; this is not the case with the pre-operational child. It does not seem however that a child of two or three is pre-operational in all areas at the same time and that the pre-operational child suddenly becomes operational; the learning of language is a case in point if one accepts Bruner's position that the young child possesses a structure of language with which to operate.¹⁹

As to the third stage of development, Bruner states:

Now the child's intellectual activity seems to be based upon an ABILITY TO OPERATE ON HYPOTHETICAL PROPOSITIONS rather than being constrained to what he has experienced or what is before him [...] Intellectual operations now appear to be PREDICATED upon the same kinds of LOGICAL OPERATIONS that are the stock in trade of the logician, the scientist, or the abstract thinker.²⁰

In the third stage then, the child can deal systematically with possibilities. Though structure is not mentioned in the above passage, it is implied; if there is a structure at the concrete operational stage, 'a fortiori' there is one at the formal operational stage.

One of the differences between the second and third stage is that in the formal operational stage, the child "commands the operations for conjuring up systematically the

¹⁹ Ibid., p. 8.

²⁰ Ibid., p. 37.

full range of alternative possibilities",²¹ while in the concrete operational stage he does not.

This general discussion of the nature, characteristics and products of operations at different age levels sheds light on the statements which summarize the developmental process attributor quoted on page 145.

Internal structures are the results of both concrete and formal operations. If structures are developed at the pre-operational stage, they are closely tied to overt action. Though the representations which the child develops are prerequisites and constitute a necessary stage in intellectual development, they are not fundamental representations; the generalizations are simple in the sense that "things are represented as equivalent in terms of sharing some common property",²² and that relationships are established between experience and action,²³ rather than internally between things and ideas or between ideas. The child at the concrete operational stage develops structures which are just as fundamental as those developed by the child at the formal operational stage though he does not command the operations.

21 Ibid., p. 37.

22 Ibid., p. 34.

23 Ibid., p. 34.

One can now draw the following conclusions concerning the extrinsic internal factors of a structure of knowledge: operations, such as disjunction, inclusion, ordering, etc. guided by the logic of classes and relations, are the means by which internal structures are developed; concrete operations are the means by which internal structures of present reality are developed; formal operations are the means by which internal structures of present reality as well as probabilities are developed.

b) The learning process attributors.- To make clear what is implied in teaching the foundations of any subject to anybody at any age in some form,²⁴ Bruner examines the processes involved in the act of learning. There is but one indirect attributor of a structure of knowledge in this section; it is indirect in the sense that it has to be inferred from Bruner's stated purpose namely, that the structure of any subject can be taught to anybody at any age in some form, and from his discussion on the course of intellectual development and its relationships to the act of learning. In other words, an attributor is formed by placing in relationship a number of scattered texts in which an explanation is made equivalent to another or connotes an equivalence.

24 Ibid., p. 12, 33, 52.

The first text describes the processes involved in the act of learning a subject:

... Learning a subject seems to involve three almost simultaneous processes. First there is ACQUISITION of new information [...] A second aspect of learning may be called TRANSFORMATION [...] A third aspect of learning is EVALUATION.²⁵

A second text describes an operation:

... Roughly an operation is a means of GETTING DATA about the real world into the mind and there TRANSFORMING them so that they can be ORGANIZED and USED selectively in the solution of problems...²⁶

The statement that an operation is a means of getting data about the real world into the mind and there transforming them is interpreted to mean the same thing as acquiring and transforming information. One can therefore state that, according to Bruner, operations are the means by which information is acquired and transformed.

A third text describes the evaluation process:

A third aspect of learning is evaluation: checking whether the way we have MANIPULATED information is adequate to the task. Is the generalization fitting, have we extrapolated appropriately, ARE WE OPERATING PROPERLY?...²⁷

The above text merely confirms the conclusion that operations are the means by which information is acquired and transformed.

25 Ibid., p. 48.

26 Ibid., p. 35.

27 Ibid., p. 48-49.

A fourth text is a conclusion to a description of the different ways by which children of different ages view things:

... Each way of looking at the phenomenon REPRESENTS THE RESULT OF AN OPERATION IN THIS SENSE, and the child's thinking is constrained by his way of pulling his observations together.²⁸

To be sure that one does not go beyond Bruner's thinking, a limitation is imposed on the interpretation of the above text. It is interpreted to mean that the results of some operations are representations; the phrase 'in this sense' suggests this interpretation.

The fifth text is taken from Bruner's discussion on concrete operations in which he states:

... Such INTERNAL STRUCTURES are of the essence. They are the INTERNALIZED SYMBOLIC SYSTEMS by which the child REPRESENTS the world...²⁹

This text provides a link between representations and internal structures such that one can at least state that some representations--symbolic systems--are internal structures.

A first conclusion is derived from the summarizing statements of the first three texts. If the processes involved in the act of learning are acquisition, transformation and evaluation and if operations are the means by which

28 Ibid., p. 36.

29 Ibid., p. 37.

information is acquired, transformed (and evaluated), it follows therefore that the processes involved in the act of learning imply the use of operations. This conclusion is confirmed in the text in which Bruner describes the process of evaluation; he suggests that one should ask in evaluating a transformation whether we have been operating properly.³⁰

A second conclusion is derived from the summarizing statements of the fourth and fifth texts. If the results of operations are representations and if some representations--the internal symbolic systems--are internal structures, it follows that the results of some operations are internal structures.

Using these two conclusions as premises, the implied major argumentation may be stated as follows: The processes involved in the act of learning imply the use of operations; but the results of some of these operations are internal structures; therefore, the processes involved in the act of learning imply the use of operations some of which result in internal structures.

B. The Modal Attributors

In the chapter on Intuitive and Analytic Thinking, Bruner makes a plea for the development of intuitive

³⁰ Ibid., p. 48.

thinking.³¹ In the context of this section of the study, the concern is with the function both modes have in the development of structure of knowledge; only those attributors which manifest explicitly or implicitly that intent are considered here.

Before proceeding with a report of the text and an analysis, it is deemed necessary to state some of the differences between intuitive and analytic thinking according to Bruner.³² First, analytic thinking "proceeds a step at a time"; intuitive thinking "does not advance in careful well-defined steps". Second, the analytic thinker can "adequately report the steps to another individual"; the intuitive thinker "rarely can provide an adequate account of how he obtained his answers". Third, the analytic thinker is aware "of the information and operations involved"; the intuitive thinker "may be unaware of just what aspects of the problem situation he is responding to".

The text in which one finds a modal attributor is taken from Bruner's discussion on the nature of intuition. He writes:

31 Ibid., p. 56.

32 Ibid., p. 57-58.

For a working definition of intuition, we do well to begin with Webster: 'immediate apprehension or cognition'. 'Immediate in this context is contrasted with 'mediated'--apprehension or cognition that depends on the intervention of formal methods of analysis and proof. Intuition implies the act of grasping the MEANING, SIGNIFICANCE, or STRUCTURE of a problem or situation without explicit reliance on the analytic apparatus of one's craft. The rightness or wrongness of an intuition is finally decided not by intuition itself but by the usual methods of proof. It is the intuitive mode, however, that yields hypotheses quickly, that hits on combinations of ideas before their worth is known. In the end, intuition by itself yields a TENTATIVE ORDERING OF A BODY OF KNOWLEDGE that, while it may generate a feeling that the ordering of facts is self-evident, aids principally by giving us a basis for moving ahead in our testing of reality.³³

The transformation of the above text yields the following pertinent statements: intuition is immediate apprehension or cognition; formal methods of analysis and proof result in mediate apprehension; the intuitive mode yields hypotheses quickly; the intuitive mode hits on combinations of ideas before their worth is known; intuition yields a tentative ordering of a body of knowledge; a tentative ordering of a body of knowledge aids principally by giving us a basis for moving ahead in our testing of reality by the more formal methods of analysis and proof.

The last statement is reinforced in the following text:

³³ Ibid., p. 60.

The complimentary nature of intuitive and analytic thinking should, we think, be recognized. Through intuitive thinking the individual may often arrive at solutions to problems which he would not achieve at all, or at best more slowly, through analytic thinking. Once achieved by intuitive methods, they should if possible be checked by analytic methods, while at the same time being respected as worthy hypotheses for such checking...³⁴

The most pertinent statements of the above are those which express the following propositions: intuition yields a tentative ordering of a body of knowledge; this tentative ordering aids principally by giving us a basis for moving ahead in our testing of reality by the more formal methods of analysis and proof. Both modes are therefore useful in ordering knowledge. But the ordering of knowledge is closely related to the concept of a structure of knowledge as revealed in the discussion of the essential attributors in Chapter V. One can therefore conclude that the intuitive and analytic modes of thinking yield an internal structure of knowledge, the intuitive tentatively and quickly, the analytic formally and systematically.

C. The Conditional Attributors

Some attributors manifest Bruner's intent to relate structure to certain habits and dispositions which can affect its acquisition.

³⁴ Ibid., p. 58.

In discussing "the role of structure in learning and how it can be made central in teaching", Bruner affirms:

... There are many things that go into learning of this kind [learning of structure], not the least of which are SUPPORTING HABITS and SKILLS that make possible the active use of the materials one has come to understand...³⁵

In the following text, Bruner calls attention to "a matter that is left unsettled even by a large-scale revision of curricula":

... Mastery of the fundamental ideas of a field involves not only the grasping of general principles, but also the development of an ATTITUDE toward learning and inquiry, toward guessing and hunches, toward the possibility of solving problems on one's own. Just as a physicist has certain attitudes about the ultimate orderliness of nature and a conviction that order can be discovered, so a young physics student needs some working version of these ATTITUDES if he is to organize his learning in such a way as to make what he learns usable and meaningful in his thinking.³⁶

Again, in the same chapter on the importance of structure, Bruner states:

Indeed, it may well be that there are certain general ATTITUDES OR APPROACHES toward science or literature that can be taught in the earlier grades that would have considerable relevance for later learning. The ATTITUDE that things are connected and not isolated is a case in point [...] 'heuristic', [...] the APPROACH one takes to solving problems [...] ATTITUDES or HEURISTIC devices that are most pervasive and useful...³⁷

35 Ibid., p. 12.

36 Ibid., p. 20.

37 Ibid., p. 27.

Summary statements of the above texts would include the following as habits and skills which support the learning of structure; certain working attitudes (toward learning and inquiry, toward guessing and hunches, toward possibility of solving problems on one's own, toward connectedness of things) are necessary to organize one's learning in a usable and meaningful form. Heuristics as defined by Bruner is 'a non-rigorous method of achieving solutions of problems'.³⁸ It is to be noted that Bruner attaches great importance to these supports of a structure of knowledge; he returns to it like a leitmotiv as evidenced from the above texts and others.^{39,40,41,42,43}

The conclusion is that concurrent to the learning of a structure of knowledge, the development of certain habits, attitudes and skills such as heuristics, guessing, following hunches, confidence in one's ability, are needed to support it if it is to be usable and meaningful.

38 Ibid., p. 63.

39 Ibid., p. 18.

40 Ibid., p. 28.

41 Ibid., p. 29.

42 Ibid., p. 63-64.

43 Ibid., p. 73.

D. The Instrumental Attributors

Instrumental attributors are understood to be those through which the author intends to convey the means by which the learning of a structure of knowledge is facilitated or takes place. Such attributors are found in a text or in several texts which implicitly or explicitly contain sentences in which the subjects are the agents, the verbs are causative and the object is the pivotal entity (e.g. a knife killed John), or which contain sentences in which the subjects are the pivotal entity, the verbs causative and the object a prepositional phrase (e.g. John was killed with a knife).

The following instrumental attributors of a structure of knowledge are considered in this section: the environment, the curriculum, the act of teaching, teaching methods, the teacher, teaching aids.

a) The environment.- The following text is taken from Bruner's discussion on intellectual development.

But the intellectual development of the child is no clockwork sequence of events; it also responds to influences from the ENVIRONMENT, notably the SCHOOL ENVIRONMENT...⁴⁴

Thus, if the environment generally and the school environment in particular influence the child in his intellectual

⁴⁴ Ibid., p. 39.

development and if intellectual development implies that there are various stages characterized by the way the child views, represents and explains the world to himself⁴⁵ then the environment generally and the school environment in particular influence the child to view, represent, and explain the world to himself. But influencing the child to view, represent, and explain the world to himself is to help him either build the foundations for developing structures (at the pre-operational stage) or develop structures (at the concrete and formal operational stages).⁴⁶

One can therefore conclude that the environment in general and the school environment in particular help the child either to build the foundations for developing structures or to develop structures.

b) The curriculum.- The first text is taken from Bruner's review of the developments that had taken place in curriculum planning during the contemporary period. He reports:

The main objective of this work [CURRICULUM development such as PSSC, SMSG, BSCS, etc.] has been to present SUBJECT MATTER effectively--that is, with due regard not only for coverage but also for STRUCTURE [...] What are the implications of emphasizing the STRUCTURE OF A SUBJECT be it mathematics or history--emphasizing it in a way that seeks to give a student as quickly as possible a sense of the FUNDAMENTAL IDEAS of a discipline?⁴⁷

45 Ibid., p. 33-34.

46 Ibid., p. 34ff.

47 Ibid., p. 2-3.

In other words, the main objective of curriculum development of that period was to present subject matter with due regard for coverage and structure so that the student acquired a sense of the fundamental ideas of a discipline.

The explicit referent for structure in this text is a discipline or a subject, not an internal structure of knowledge; but indirectly Bruner also refers to an internal structure of knowledge when he suggests that the presentation of subject matter with due regard for structure might give to the student a sense of the fundamental ideas of a discipline. To sense the fundamental ideas of a discipline is to understand them. If one recalls at this point that the fundamental ideas of a discipline are constituent elements of a structure of knowledge, one can conclude that curriculum developed with due regard for the structure of a subject matter helps the student to acquire at least a constituent element of an internal structure of knowledge.

In the second text which follows, Bruner explains his notion of the spiral curriculum:

... A CURRICULUM as it develops should revisit these BASIC IDEAS repeatedly, building upon them until the student has grasped the full formal apparatus that goes with them. Fourth grade children can play absorbing games governed by the PRINCIPLES of topology and set theory, even discovering new 'moves' or theories. They can grasp the IDEA of tragedy and the basic human plights represented in myth. But they cannot put these ideas into formal language or manipulate them as grownups can. There is much still to be learned about the 'SPIRAL CURRICULUM' that turns back on itself at HIGHER LEVELS...⁴⁸

In brief, a spiral curriculum is a curriculum which turns back on itself at higher levels to revisit basic ideas and principles until the student has grasped the full formal apparatus that goes with them.

The spiral curriculum allows revisits of basic ideas and principles of a subject or discipline with due regard for the thought forms of the learner i.e. his ways of expressing and manipulating. But since the basic ideas and principles of a subject or discipline have been decided upon by the scholars who have vision, competence and understanding of the fundamental structure of a field⁴⁹ i.e. by those who possess an internal structure, can express it and manipulate it formally, the spiral curriculum therefore becomes a means of helping the learner to gradually develop a fundamental internal structure of knowledge comprising basic ideas and

48 Ibid., p. 13.

49 Ibid., p. 19.

principles which can be expressed and manipulated formally.

In the third text, Bruner extends his concept of curriculum to the humanities. He states:

If the hypotheses with which this section was introduced is true--that any subject can be taught to any child in some honest form--then it should follow that a CURRICULUM ought to be BUILT AROUND THE GREAT ISSUES, PRINCIPLES AND VALUES that a society deems worthy of the continual concern of its members [...] If it is granted, for example, that it is desirable to give children an awareness of the meaning of human tragedy and a sense of compassion for it, is it not possible at the earliest appropriate age to teach the literature of tragedy in a manner that illuminates but does not threaten? [...] In time, one GOES BEYOND to more COMPLEX VERSIONS of the same kind of literature or simply REVISITS some of the same books used earlier [...] It is not amiss to urge that actual CURRICULA be reexamined with an eye to the issues of CONTINUITY and DEVELOPMENT...⁵⁰

Curriculum ought to be constructed around great issues, principles, and values with an eye to continuity and development from simple to complex versions.

Bruner implants here the idea that the principles of continuity and development are applicable to the construction of curricula in the humanities. The complex versions to which he refers are the 'great issues, principles and values' deemed worthy of concern by the members of society; their level of sophistication is interpreted to be at least equivalent to the basic ideas and principles of a scientific discipline; they are the constituent elements of an internal structure of

⁵⁰ Ibid., p. 52-54.

knowledge. As with basic ideas and principles, the great issues, principles and values are revisited with due regard for the thought forms of the learner ('with an eye to continuity and development'). This kind of curriculum helps the learner to go beyond the simple versions of an issue, a principle or value to the more complex versions, from elementary internal structures of knowledge to more fundamental internal structures of knowledge.

c) Teaching.- A first text is taken from the introduction to the course of intellectual development:

... The task of TEACHING a subject to a child at any particular age is one of representing the STRUCTURE of that subject in terms of the child's way of viewing things. The task can be thought of as one of translation...⁵¹

A second text in which one finds an instrumental attributor related to teaching is a follow-up of a long quote from the paper presented by B. Inhelder on the 'ways in which the child could be moved along faster through the various stages of intellectual development in mathematics and physics'.⁵² Bruner states:

51 Ibid., p. 33.

52 Ibid., p. 40-41.

A comparable approach can surely be taken to the teaching of social studies and literature. [...] Can one TEACH THE STRUCTURE of literary forms by presenting the child with the first part of a story and then having him complete it in the form of a comedy, a tragedy, or a farce--without ever using such words?...⁵³

The first text describes the task of teaching as one of translating the structure of a subject in terms of the child's way of viewing things; the second text suggests an application to the teaching of the structure of literary forms. This task of translation recurs frequently in The Process of Education.⁵⁴ Since by its very nature, teaching is a triadic relationship, it follows that the purpose of translating the structure of a subject in the appropriate thought forms of the learner⁵⁵ is intended to help the child develop internal structures commensurate with his stage of intellectual development.

d) Teaching methods.- Other attributors refer more specifically to teaching methods. Bruner relied heavily on B. Inhelder's report to the Woods Hole Conference members. Inhelder⁵⁶ suggested that the teacher use special concrete materials that provide the child with an opportunity to

⁵³ Ibid., p. 46-47.

⁵⁴ Ibid., p. 39, 40, 43, 52, 53, 73.

⁵⁵ Ibid., p. 73.

⁵⁶ Ibid., p. 41-46.

progress through confrontation to teach him the idea of invariance and reversibility operations, devise experiments that force the child to pay attention to several aspects of a phenomenon, teach the structure of a subject in its axiomatic order rather than in its historical order (though not always), have children play games which require the use of concrete logical operations, have children do series of exercises at an early age in manipulating, classifying and ordering objects in ways that highlight basic operations of logical addition, multiplication, inclusion, serial ordering, and the like.

In the same context, Bruner asks:

... Is it worth while to train the young inductively so that they may DISCOVER the BASIC ORDER OF KNOWLEDGE before they can appreciate its formalism?...⁵⁷

Bruner here suggests that children should be trained to discover the basic order of knowledge. There is no mention made here of a structure of knowledge but there is mention of a cognate term, order. In the light of the analysis made in Chapter V of the relationship between structure and order, of the context and of the orientation of The Process of Education, one can surmise that Bruner implies a structure of knowledge.

⁵⁷ Ibid., p. 47.

One finds confirmation of this statement in the following text in which he discusses the relationship between attitudes towards learning and discovery. He states:

... Just as a physicist has certain attitudes about the ultimate orderliness of nature and a conviction that order can be discovered, so a young physics student needs some working version of these attitudes if he is to organize his learning in such a way as to make what he learns usable and meaningful in his thinking. To instill such attitudes [toward learning] by teaching requires something more than the mere presentation of fundamental ideas. Just what it takes to bring off such teaching is something on which a great deal of research is needed, but it would seem that an important ingredient is a SENSE OF EXCITEMENT ABOUT DISCOVERY--DISCOVERY OF REGULARITIES OF PREVIOUSLY UNRECOGNIZED RELATIONS AND SIMILARITIES BETWEEN IDEAS, with a resulting sense of self-confidence in one's abilities. Various people who have worked on curricula in science and mathematics have urged that it is possible to PRESENT THE FUNDAMENTAL STRUCTURE OF A DISCIPLINE in such a way as to preserve some of the EXCITING sequences that lead a student to discover for himself.⁵⁸

To summarize, one can state: that the experience of learning general principles through discovery of regularities of previously unrecognized relations and similarities between ideas is rewarding in terms of intellectual excitement; that the learner is motivated to discover order, to organize his learning in such a way as to make what he learns usable and meaningful in his thinking.

The following text further explains the discovery approach:

⁵⁸ Ibid., p. 20.

There is a range of problems that have to do with how much emphasis should be placed on acquisition, transformation, and evaluation in a learning episode --getting facts, manipulating them, and checking one's ideas. Is it the case, for example, that it is best to give the young child a minimum set of facts first and then encourage him to draw the fullest set of implications possible from this knowledge? In short, should an episode for a young child contain little new information but emphasize what can be done to go beyond that bit on one's own? One teacher of social studies has had great success with fourth-graders through this approach: he *begins*, for example, with the fact that civilizations have most often begun in fertile river valleys--the only 'fact'. The students are encouraged in class discussion to figure out why this is the case and why it would be less likely for civilizations to start in mountainous country. The effect of this approach, essentially the *TECHNIQUE OF DISCOVERY*, is that the child generates information on his own, which he can then check or evaluate against the sources, getting more new information in the process...⁵⁹

The discovery approach thus implies the episodic and cyclical application of the processes of the act of learning --acquisition of knowledge, transformation and evaluation resulting in recognition of regularities of relations and similarities between ideas.

But to recognize regularities in previously unrecognized relations and to perceive similarities between ideas is to develop structures of knowledge if the conclusions of the previous discussions on the essential and denotative attributors are plausible.

⁵⁹ Ibid., p. 50-51.

The method of discovery as an approach in teaching and learning is therefore instrumental in helping the learner to develop structures of knowledge be they elementary or fundamental.

According to Bruner, a different approach to examinations can also foster the development of structures. He states:

... Whether an examination is of the 'objective' type involving multiple choices or of the essay type, it can be devised so as to EMPHASIZE AN UNDERSTANDING OF THE BROAD PRINCIPLES OF A SUBJECT. Indeed, even when one examines on detailed knowledge, it can be done in such a way as to require an UNDERSTANDING by the student of the CONNECTEDNESS BETWEEN SPECIFIC FACTS [...] The searching examination is not easy to make...⁶⁰

Once again, if the entities structure, principles and ideas have been plausibly interpreted in the preceding chapters, one can say that the learner can be helped to develop an internal structure of knowledge through examinations that emphasize its understanding.

e) The teacher.- Since the act of teaching implies that there is a person who teaches, it is obvious that the teacher presumably contributes to the development of internal structures of knowledge. Yet Bruner elaborates on the teacher's role as follows:

⁶⁰ Ibid., p. 30-31.

... Yet, withal, the TEACHER constitutes the PRINCIPAL AID in the teaching process as it is practiced in our schools [...]

It takes no elaborate research to know that communicating knowledge depends in enormous measure upon one's MASTERY OF THE KNOWLEDGE to be communicated [...]

The teacher is not only a COMMUNICATOR but a MODEL. Somebody who does not see anything beautiful or POWERFUL about mathematics is not likely to ignite others with a sense of the intrinsic excitement of the subject [...]

The teacher is also an immediately PERSONAL SYMBOL of the educational process, a figure with whom students can identify and COMPARE themselves ...⁶¹

The role of the teacher as communicator, model and identification figure is related partly to his mastery of the knowledge to be communicated. On this point, Bruner is explicit only with respect to the role of the teacher as communicator but it is implied in the other roles he assigns to the teacher; the teacher who masters mathematics and sees its power is a model and a symbol with whom students can identify or compare themselves.

There is a subtle but strong implication that those who teach should learn their subject⁶² if they are to teach its fundamental structure.⁶³

61 Ibid., p. 88-90.

62 Ibid., p. 88.

63 Ibid., p. 12.

The teacher therefore is the principal aid in the development of structures of knowledge.

f) Aids to teaching.- In the final chapter of The Process of Education, Bruner discusses aids to teaching. This section purports to report and analyze the two texts in which these kinds of attributors are obvious.

The first text is taken from Bruner's description of the various teaching aids. He states:

... Some of them [devices for vicarious experience] are designed to present material to the student of a kind that would not be available to him in his ordinary school experience [...]

A second type of teaching aid [MODEL DEVICES] has the function of HELPING the student to GRASP THE UNDERLYING STRUCTURE of a phenomenon--to sense the genotype behind the phenotype, to use terms from genetics. The well wrought laboratory experiment or demonstration is the classic aid in such activity. A closer look at our efforts to GET STUDENTS to GRASP STRUCTURE indicates that there are many other devices and exercises that have the same function. The effort to give visible embodiment to ideas in mathematics is of the same order as the laboratory work [...]

But there are other, more subtle devices that can be and are being used TO LEAD THE STUDENT to a sense of the CONCEPTUAL STRUCTURE of things he observes [...] 'sequential programs' [...] designed TO LEAD THE STUDENT to an understanding of BASIC IDEAS AND STRUCTURES.⁶⁴

The second text summarizes Bruner's view on teaching aids. He states:

64 Ibid., p. 81-82.

In sum, then, there exist devices TO AID THE TEACHER in extending the student's range of experience, in HELPING HIM TO UNDERSTAND THE UNDERLYING STRUCTURE of the material he is learning, and in dramatizing the significance of what he is learning...⁶⁵

The two texts may be summarized as follows: certain devices, such as models, laboratory experiments, demonstrations, sequential programs, aid the teacher in helping the student understand the underlying structure of the material he is learning--the conceptual structure of things he observes.

2. Eighth Evolving List of Derived Propositions

As the conclusions reached in this chapter touch on aspects of a fundamental internal structure of knowledge that are quite different from those in the preceding chapters, a preliminary summary is not deemed necessary. These conclusions are incorporated in Propositions 9 and 10 of the eighth evolving list of derived propositions which follows:

Propositions 1 to 8: Same as the seventh evolving list.

Proposition 9: A fundamental internal structure of knowledge is developed intuitively or analytically as the result of the use of concrete or formal operations aided by supportive habits, skills and attitudes in the processes involved in the act of learning.

⁶⁵ Ibid., p. 84.

- a) The intuitive mode yields a tentative and quick ordering of knowledge, while the analytic mode orders knowledge more formally and systematically;
- b) operations are internal and reversible actions such as disjunction, inclusion, ordering, etc.;
- c) concrete operations are involved in the structuring of present reality while formal operations are involved in probability structuring; the types of operations used, also depend on a person's stage of development;
- d) supportive habits, skills, and attitudes refer to guesses, follow-ups on hunches, problem-solving strategies, connectedness of things, inherent order in nature, confidence in one's ability to discover, etc.;
- e) the processes involved in the act of learning are acquisition of knowledge, transformation of this knowledge and evaluation of the transformations.

Proposition 10: A fundamental internal structure of knowledge may be developed through the environment in general and the school environment in particular. In the school environment, it is developed by means of:

- a) a spiral curriculum based on the structure of a discipline or subject, built with an eye for

continuity and development through episodic units (units which reflect the processes of acquisition, transformation and evaluation) with due regard for the thought forms of the learner, and which turns back on itself to revisit basic ideas and leads the learner to the formal apparatus that goes with the learning of fundamental structures;

- b) teaching which translates the structure of a subject in the appropriate thought forms of the learner;
- c) teaching methods such as confrontation with apparently conflicting facts, experiments which force the learner to pay attention to several aspects of a phenomena, games which highlight basic operations--all under the umbrella of the discovery approach. This approach consists in the finding of regularities of previously unrecognized relations and similarities between ideas through the incorporation of the processes involved in the act of learning in episodic and cyclical units;
- d) searching examinations which emphasize understanding of broad principles and connectedness between specific facts;
- e) teachers who, as scholars, communicators, models, personal symbols, are the principal aids;

- f) teaching aids such as models, laboratory experiments, demonstrations, sequential programs which embody structures.

The analysis of the agentive attributors has yielded propositions which state the external and internal effectors of a structure of knowledge. In the next chapter, the purposive attributors are analyzed with a view to determining another set of extrinsic factors on which a fundamental internal structure depends, namely, the reasons why one would seek to learn structures and the reasons why those responsible for the education of the young would be concerned with their learning of structures.

CHAPTER IX

THE PURPOSIVE ATTRIBUTORS

Chapter VIII analyzed the agentive attributors with the purpose of determining the agents of a fundamental internal structure of knowledge and their mode of action as effectors. This chapter purports to analyze the purposive attributors which are intended to convey some understanding about the intentions, the motives of the human agents.

Since the learner himself is the principal agent for the development or learning of structures, one must look for attributors which would point to the reasons why he would be moved to purposively develop or learn structures. On the other hand, it is also possible that some instrumental agents such as educators would have reasons, not always apparent to the learner, for making the development or learning of structures the object of their activities; one must therefore look for attributors which would point to the reasons why an instrumental agent would purposively set out to do so. Accordingly, the purposive attributors have been grouped into two classes: the purposive attributors related to the learner and the purposive attributors related to the educator.

Purposive attributors are found, in sentences in which, implicitly or explicitly, the author of the communication uses purposive prepositions such as 'for', 'because' in reference

to the development or learning of structures by the agents.

1. Analysis

A. The Purposive Attributors Related to the Learner

The concern here is with what prompts the learner to develop or to learn structures.

a) Learning structures--Interest.- In his conclusion of the chapter of Motives for Learning, Bruner states:

To sum up the matter, motives for learning must be kept from going passive in an age of spectatorship, they must be based as much as possible upon the arousal of INTEREST IN WHAT THERE IS TO BE LEARNED, and they must be kept broad and diverse in expression...¹

It is obvious that interest is the main motive for learning whatever is to be learned. The attributor here is expressed in the phrase 'what there is to be learned'; there is no direct reference to an internal structure of knowledge. One can, however, establish a link between these two expressions by referring to Bruner's Introduction to The Process of Education in which he indicates his intention of developing a theme pertaining to the "role of structure in learning and how it can be made central in teaching".² He states:

¹ Jerome S. Bruner, The Process of Education, Cambridge, Harvard University Press, 1960, p. 80.

² Ibid., p. 11.

Given the importance of this theme, much too little is known about how to teach fundamental structure effectively or how to provide learning conditions that foster it. Much of the discussion in the chapter devoted to this topic has to do with ways and means of achieving such teaching and learning and with the kinds of research needed to help in preparing curricula with emphasis on structure.³

It is almost a truism to state that the thrust of The Process of Education is in the teaching and learning of structures and one can refer to numerous statements to support it particularly when such cognate terms as 'grasping' and 'understanding', 'ideas', 'principles'⁴ are taken into account.

Therefore, if 'whatever is to be learned' is interpreted to mean structure then one can conclude from the above that interest is a main motive for learning structures.

b) Learning structures--Curiosity and lure of discovery.- In a discussion on the balance between extrinsic and intrinsic rewards, Bruner states:

... There has been much written on the role of reward and punishment in learning, but very little indeed on the role of INTEREST and CURIOSITY and the lure of DISCOVERY...⁵

3 Ibid., p. 12.

4 Ibid., p. 2, 6-9, 13, 17, 20, 23, 25, 29, 31, 33, 35, 37, 44, 46, 47, 51, 58, 60, 62, 81, 82, 84.

5 Ibid., p. 50.

Bruner implies that interest or intellectual excitement,⁶ curiosity, and the lure of discovery are sufficient motives for learning and that less emphasis should be placed on extrinsic rewards such as grades.⁷ In view of the perspective of The Process of Education, one must assume that these motives apply as well to the learning of structures.

c) Learning structures--Desire for mastery and approval of others.- In some of his descriptions of motives the learner might have for learning, Bruner states:

There will always be, perhaps, MIXED MOTIVES for learning among schoolchildren. There are PARENTS and TEACHERS to be pleased, one's CONTEMPORARIES to be dealt with, one's sense of MASTERY to be developed.⁸

Other expressions such as 'gain in understanding',⁹ pay-off in terms of increased power and understanding¹⁰ refer to similar motives.

The motives stated apply to learning in general but again here because of the importance Bruner gives to structure, it is implied that the statement applies equally to the learning of structures, particularly the phrase 'one's sense of mastery to be developed'.

6 Ibid., p. 31.

7 Ibid., p. 49, 51.

8 Ibid., p. 72.

9 Ibid., p. 49.

10 Ibid., p. 51.

Thus in addition to other motives for learning structures such as parental, teacher and peer approval there is the desire to master the subjects, to broaden and deepen one's knowledge in terms of basic and general ideas.¹¹

d) Learning structures--Other motives.- Several pages of the chapter on Motives for Learning are devoted to a discussion of what Bruner calls. the dangers of meritocracy and competitiveness.¹² He states:

... If it should become the case that certain highly DESIRABLE JOBS are assured to WINNERS of National Merit Scholarships, then we may be quite sure that it will not be long before teaching and learning reflect the importance of such scholarships...¹³

The implication is that success in the educational and professional worlds can become a motive for learning; one deepens and broadens one's knowledge for the extrinsic rewards it provides while for Bruner motives "must be based as much as possible upon the arousal of interest in what there is to be learned, [...]".¹⁴

Thus for Bruner extrinsic rewards such as success in the educational and professional worlds vitiate the intended result of learning structures i.e. a deepening and broadening

11 Ibid., p. 17.

12 Ibid., p. 80.

13 Ibid., p. 78.

14 Ibid., p. 80.

of one's knowledge.

B. The Purposive Attributors Related to the Educator

In addition to the motives the learner might have for developing internal structures of knowledge, those responsible for his education might have reasons for helping the learner develop them. Some of these reasons are based on the consequences and results of having learned structures; they may or may not be apparent initially to the learner. Attributors which introduce the functional attributes of structures as reasons why they should be developed or learned reflect this concern.

A first text in which an attributor is found is Bruner's conclusion of a discussion on transfer, continuity of learning, curricula, attitudes, discovery. He states:

... Inherent in the preceding discussions are at least four general CLAIMS that can be made FOR teaching the FUNDAMENTAL STRUCTURE of a subject.

The first is that UNDERSTANDING FUNDAMENTALS makes a subject MORE COMPREHENSIBLE [...]

The second point related to HUMAN MEMORY [...] What LEARNING GENERAL OR FUNDAMENTAL PRINCIPLES does is to ensure that memory loss will not mean total loss, that what remains will permit us to reconstruct the details when needed [...]

Third, an UNDERSTANDING OF FUNDAMENTAL PRINCIPLES AND IDEAS, [...] appears to be the main road to adequate 'TRANSFER OF TRAINING' [...]

The fourth claim FOR EMPHASIS ON STRUCTURE AND PRINCIPLES in teaching is that by constantly reexamining material taught in elementary and secondary schools for its fundamental character, one is able to NARROW THE GAP between 'ADVANCED' knowledge and 'ELEMENTARY' KNOWLEDGE...¹⁵

Since learning is a correlative of teaching, one can assume that the claims for teaching structures are at the same time the claims for learning structures. The consequences and results of learning structures--comprehensibility, aid to memory, transfer, link between levels of knowledge--become purposes for teachers who value them.

Among these purposes, Bruner singles out transfer of principles. Taking his cue from Benjamin Franklin's distinction between the two kinds of useful learning¹⁶--skills and general understanding--Bruner describes the kind of learning which consists initially of a general idea, "which can then be used as a basis for recognizing subsequent problems as special cases of the idea originally mastered".¹⁷ He continues:

The continuity of learning that is produced by the second type of transfer, transfer of principles is dependent upon mastery of the structure of the subject matter, [...] that is to say, in order for a person to be able to recognize the applicability or inapplicability of an idea to a new situation and to broaden his learning thereby, he must have clearly in mind the general nature of the phenomenon with which he is dealing. THE MORE FUNDAMENTAL OR BASIC IS THE IDEA HE HAS LEARNED, almost by definition, THE GREATER WILL BE ITS BREADTH OF APPLICABILITY TO NEW PROBLEMS...¹⁸

16 Ibid., p. 4-5.

17 Ibid., p. 17.

18 Ibid., p. 18.

The following text also contains a purposive attributor:

... This [giving students an understanding of the fundamental structure of whatever subjects we chose to teach] is a minimum requirement for USING KNOWLEDGE, for bringing it to BEAR ON PROBLEMS AND EVENTS one encounters OUTSIDE a classroom--or IN classrooms one enters later in one's training...¹⁹

Several texts point to the utilization of knowledge as a principal objective in learning structures.²⁰

The implication is clear: structures should be learned because they enable a person to recognize the applicability or inapplicability of an idea to new situations and problems. Stated briefly, the conclusion is that structures should be learned because they enable a person to use his or her knowledge.

Another set of reasons may evolve from the educator's or a culture's appreciation of intellectual values.²¹ The following text expresses this point of view:

We may take as perhaps the most general objective of education that it CULTIVATE EXCELLENCE, but it should be clear in what sense this phrase is used. It here refers not only to schooling the better student but also to helping each student ACHIEVE HIS OPTIMUM INTELLECTUAL DEVELOPMENT. Good teaching that EMPHASIZES THE STRUCTURE OF A subject is probably even more valuable for the less able student than the gifted one, for it is the former rather than the latter who is most easily thrown off the track by poor teaching...²²

19 Ibid., p. 11-12.

20 Ibid., p. 4, 5, 10-13, 20, 63.

21 Ibid., p. 73.

22 Ibid., p. 9.

It is apparent that Bruner considers the learning of structures, the correlative here of teaching, as most valuable in achieving optimum intellectual development.²³ It should therefore become an intended result of the educational enterprise.

2. Ninth and Final Evolving List of Derived Propositions

This chapter exhausts the analysis of attributors within the limits of this research. The list of derived propositions which follows is therefore the final evolving list. Propositions 11 and 12 incorporate the conclusions reached in this chapter.

- Proposition 1: A fundamental internal structure of knowledge is not only the knowledge of facts, of techniques, of specific topics and skills, of devices, of recipes:
- a) Facts express the connectedness of things;
 - b) knowledge of facts must be understood in the context of structure;
 - c) specific topics and skills are uneconomical;
 - d) devices and recipes are often applied without understanding their significance or connectedness;
 - e) a fundamental internal structure of knowledge implies that high-level knowledge has been sensed

²³ Ibid., p. 70.

behind low-level information and that acquired facts (or information) have been organized or connected in terms of principles and ideas through the process of transformation.

Proposition 2: A fundamental internal structure of knowledge is somewhat like a general picture, somewhat like a model, somewhat like a pattern, somewhat like a theory, somewhat like a genotype:

- a) it has a recognition attribute in that, like a general picture, it permits one to recognize the relations between things one encounters now as the same kind of relations between things encountered earlier;
- b) it has a comprehension attribute in that, like a model or a theory or a pattern, it is instrumental in understanding other things;
- c) it has a generative attribute in that, like a model, it is instrumental in generating other things from it;
- d) it has a retention attribute in that like a pattern or a theory, it helps one to retain what has been understood;
- e) it has a cognitive aspect in that, like a genotype, it implies that one has sensed high-level knowledge behind low-level information.

Proposition 3: A fundamental internal structure of knowledge is useful in:

- a) achieving general transfer, i.e. in recognizing, because of its breadth of applicability,
 - that relations between things one encounters now are the same kind of relations between things one encountered earlier;
 - that something is a specific instance of a more general case;
- b) comprehending other things, i.e. it makes other things understandable;
- c) providing for continuity in the expansion and deepening of one's knowledge, that is, other things can be generated from structure i.e. other observable characteristics, effects, etc. can be hypothesized;
- d) retaining what has been understood, i.e. it does not overload the memory capacities and permits reconstruction of details.

Proposition 4: A fundamental internal structure, fundamental principles, fundamental ideas and attitudes are different but closely related entities. Specifically,

- a) a fundamental idea by itself, or as a rule of operation i.e. as a fundamental principle is a

constituent part of a fundamental structure of knowledge;

- b) a fundamental idea subsumes a fundamental principle in the sense that it is its logical antecedent;
- c) attitudes refer to the learner's cognitive set while he is in the process of structuring;
- d) a fundamental internal structure of knowledge subsumes a fundamental idea and low-level knowledge;
- e) a fundamental idea as a rule of operation i.e. as a fundamental principle has wide and powerful applicability and therefore makes non-specific transfer possible.

Proposition 5: A fundamental internal structure of knowledge implies objectively, regular and congruous relations between two levels of knowledge and subjectively, the grasping, or understanding, or learning of these relations. A vast network of relations is implied:

- a) relations amongst the things themselves;
- b) relations amongst facts which express the connectedness of things;
- c) relations between facts and elementary principles (this could be construed as an elementary structure);
- d) relations between facts and a fundamental principle

or between elementary and fundamental principles
(a fundamental structure).

Proposition 6: A fundamental internal structure of
knowledge is an internalized symbolic system:

- a) which is the result of operations of classification and relationships;
- b) by means of which the learner represents his view of the world;
- c) and with which he then operates on its variants.

Proposition 7: A fundamental internal structure of
knowledge as a consequence of its usefulness (general
transfer, continuity, retention) is more economical
than the knowledge of specific topics and skills.

Proposition 8: A fundamental internal structure of
knowledge is:

- a) comprehensible, i.e. it makes other things understandable in terms of relationships;
- b) simple, i.e. it is free of complex details;
- c) powerful, i.e. it has the quality of effective applicability to problems and situations;
- d) effective, whether the mode of thought is intuitive or analytic; intuitively, as when one operates quickly and with facility; analytically, as when one operates more systematically and formally;
- e) representable, i.e. it can be embodied in a

symbolical mode as in a formula or in a concrete mode as in a model device.

- Proposition 9: A fundamental internal structure of knowledge is developed intuitively or analytically as a result of the use of concrete or formal operations aided by supportive skills and attitudes in the processes involved in the act of learning;
- a) the intuitive mode yields a tentative and quick ordering of knowledge, while the analytic mode orders knowledge more formally and systematically;
 - b) operations are internal and reversible actions such as disjunction, inclusion, ordering, etc.;
 - c) concrete operations are involved in the structuring of present reality while formal operations are involved in probability structuring; the type of operations used also depend on a person's stage of development.
 - d) supportive habits, skills, and attitudes refer to guesses, follow-ups on hunches, problem-solving strategies, connectedness of things, inherent order in nature, confidence in one's ability to discover, etc.;
 - e) the processes involved in the act of learning are acquisition of knowledge, transformation of this knowledge and evaluation of the transformations.

Proposition 10: A fundamental internal structure of knowledge may be developed through the environment in general and the school environment in particular. In the school environment, it is developed by means of:

- a) a spiral curriculum based on the structure of a discipline or subject, built with an eye for continuity and development through episodic units (units which reflect the processes of acquisition, transformation and evaluation) with due regard for the thought forms of the learner, which turns back on itself to revisit basic ideas and leads the learner to the formal apparatus that goes with the learning of fundamental structures;
- b) teaching which translates the structure of a subject in the appropriate thought forms of the learner;
- c) teaching methods such as confrontation with apparently conflicting facts, experiments which force the learner to pay attention to several aspects of a phenomenon, games which highlight basic operations--all under the umbrella of the discovery approach. This approach consists in the finding of regularities of previously unrecognized relations and similarities between ideas through the

incorporation of the processes involved in the act of learning in episodic and cyclical units;

- d) searching examinations which emphasize understanding of broad principles and connectedness between specific facts;
- e) teachers who, as scholars, communicators, models, personal symbols are the principal aids;
- f) teaching aids such as models, laboratory experiments, demonstrations, sequential programs which embody structures.

Proposition 11: A fundamental internal structure of knowledge is sought by the learner for motives internal and external to himself.

- a) The internal motives may be: interest or intellectual excitement, curiosity, lure of discovery, desire for deep and broad knowledge, mastery, intellectual excellence;
- b) the external motives may be: grades, approval of others, success in the educational and professional worlds.

Proposition 12: A fundamental internal structure should be learned according to some interested in the educational enterprise because it enables a person through its attributes to use his or her knowledge and because it is valuable in achieving optimum

intellectual development (intellectual excellence)
i.e. in utilizing fully his or her intellectual
powers.

This list of derived propositions concerning a fundamental internal structure of knowledge must now be translated into the classification schemes presented in the first part of this report and integrated.

PART III

BRUNER'S EXPLANATIONS

CHAPTER X

BRUNER'S EXPLANATION AS TRANSLATED AND INTEGRATED

As a result of analysis, the ninth evolving list of derived propositions about a fundamental internal structure of knowledge is assumed to reflect a plausible interpretation of the attributors found in The Process of Education. To obtain a clearer understanding of a fundamental internal structure of knowledge, one must first analyze these propositions in terms of their reference to different aspects of a fundamental internal structure of knowledge, and secondly, integrate these aspects.

There are therefore two important questions to which an answer is sought in this chapter: to what particular aspects(s) of a fundamental internal structure does each proposition (or sub-propositions) refer? How are these particular aspects related? Only when the answers to these questions of translation and integration have been formulated, can one be reasonably sure that Bruner's explanation of his concept of a fundamental internal structure of knowledge as presented in The Process of Education has been brought to light.

The classification schema of definitions presented earlier provides a useful framework for the task of translation and integration; first, the various aspects under which the

propositions can be translated are comprised in the schema and secondly, the relationships between the various aspects emerge from the relationships inherently present in the schema.

The present chapter purports to report the results of the two processes of translation (Section 1) and integration (Section 2).

1. Translation

As a technique of presentation, the categories of the classification schema of definitions have been regrouped under six broad questions: What are the nominal referents of a fundamental internal structure of knowledge? What are its physical components? What are its logical components? What are its attributes? What are its effectors? What are the intentions or motives of the human agents?

Each question is discussed according to the following plan: the meaning of the question; the list of pertinent propositions; the harmonization of propositions, if necessary; the kind of definition they represent.

A. What are the Nominal Referents of a Fundamental Internal Structure of Knowledge?

A nominal referent in this research is one which represents another whole entity presumably better known but

which acts as intermediary between the word which represents the pivotal entity and the pivotal entity itself. A nominal referent does not refer to the class to which a pivotal entity belongs nor to its components.

The question could be reformulated as follows: To what other entities is a fundamental internal structure of knowledge compared or associated by means of other words?

The following propositions are pertinent:

Proposition 1: A fundamental internal structure of knowledge is not only the knowledge of facts, of techniques, of specific topics and skills, of devices, or recipes.

- a) Facts express the connectedness of things;
- b) knowledge of facts must be understood in the context of structure;
- c) specific topics and skills are uneconomical;
- d) devices and recipes are often applied without understanding their significance or connectedness;
- e) a fundamental internal structure of knowledge implies that high-level knowledge has been sensed behind low-level information and that acquired facts (or information) have been organized or connected in terms of principles and ideas through the process of transformation.

Proposition 2: A fundamental internal structure of knowledge is somewhat like a general picture, somewhat like a model, somewhat like a pattern, somewhat like a theory, somewhat like a genotype.

- a) It has a recognition attribute in that, like a general picture, it permits one to recognize the relations between things one encounters now as the same kind of relations between things one encountered earlier;
- b) it has a comprehension attribute in that, like a model or a theory or a pattern, it is instrumental in understanding other things;
- c) it has a generative attribute in that, like a model, it is instrumental in generating other things from it;
- d) it has a retention attribute in that like a pattern or a theory, it helps one to retain what has been understood;
- e) it has a cognitive aspect in that, like a genotype, it implies that one has sensed high-level knowledge behind low-level information.

A fundamental internal structure of knowledge can therefore be nominally referred to in two ways--negatively and positively. It may be referred to negatively by stating that it is not only knowledge of facts, of techniques, of

specific topics and skills, of devices, of recipes (Proposition 1): it may be referred to positively by using mainly analogical terms such as 'general picture', 'model', 'pattern', 'theory', 'genotype' and attending to their significant aspects (Proposition 2).

With respect to the classification schema of definitions, the nominal referents are related to the nominal definitions.

B. What are the Physical Components of a Fundamental Internal Structure of Knowledge?

In the above question, it is analogically that the term physical is used. Just as in a physical object one finds material and formal components so does one find them, 'sui generis', in a fundamental internal structure of knowledge.

The above question could be reformulated in several ways as follows: What are the inner passive and active components on which depends the existence of a fundamental internal structure of knowledge? What is changed and what changes? What is transformed and what is transforming?

While for purposes of analysis the material and formal components may be dissociated in one's mind, they cannot be existentially; the entity depends for its existence as an entity on the two components.

The following propositions belong to that category:

Proposition 1: A fundamental internal structure of knowledge is not only the knowledge of facts, of techniques, of specific topics and skills, of devices, of recipes:

- a) Facts express the connectedness of things;
- b) knowledge of facts must be understood in the context of structure;
- c) specific topics and skills are uneconomical;
- d) devices and recipes are often applied without understanding their significance or connectedness;
- e) a fundamental internal structure of knowledge implies that high-level knowledge has been sensed behind low-level information and that acquired facts (or information) have been organized or connected in terms of principles and ideas through the process of transformation.

Proposition 4: A fundamental internal structure, fundamental principles, fundamental ideas and attitudes are different but closely related entities. Specifically,

- a) a fundamental idea by itself, or as a rule of operation, i.e. as a fundamental principle is a constituent part of a fundamental structure of knowledge;
- b) a fundamental idea subsumes a fundamental principle

- in the sense that it is a logical antecedent;
- c) attitudes refer to the learner's cognitive set while he is in the process of structuring;
- d) a fundamental internal structure of knowledge subsumes a fundamental idea and low-level knowledge;
- e) a fundamental idea as a rule of operation, i.e. as a fundamental principle, has wide and powerful applicability and therefore makes non-specific transfer possible.

Proposition 5: A fundamental internal structure of knowledge implies objectively, regular and congruous relations between two levels of knowledge and subjectively, the grasping or understanding or learning of these relations. A vast network of relations is implied:

- a) relations amongst the things themselves;
- b) relations amongst facts which express the connectedness of things;
- c) relations between facts and elementary principles (this could be construed as an elementary structure);
- d) relations between facts and a fundamental principle or between elementary and fundamental principles (a fundamental structure).

It is obvious from the above that there are different forms of knowledge. One must therefore, as a starting point, identify the different forms of knowledge as implied in the

propositions.

Knowledge may be in the form of facts, of techniques, of skills, of principles, of ideas, of structures (Propositions 1, 4, 5). Since the pivotal entity is a fundamental internal structure of knowledge, one must analyze its relationship to other forms of knowledge.

Distinctions are implied between facts and principles; regular and congruous relations between them are suggested (Propositions 1, 5). In addition, a sharper distinction in terms of levels of knowledge can be drawn from Proposition 5: facts constitute a low level of knowledge and principles constitute a high level.

A fundamental structure of knowledge attends to the network of relations between two orders of knowledge (sub-proposition 1 e) and sub-proposition 5 d). Relations between facts and fundamental principles or between elementary and fundamental principles or more accurately fundamental ideas before they are used as rules of operations (Proposition 4) are established based on their regularity and on the similarity of the ideas they express. Relations between facts and elementary principles are established on the same basis. Thus fundamental principles if not directly related to facts are imbedded in facts through elementary principles.

This also explains why knowing facts, formulas or techniques or even principles as such is not enough

(Propositions 1, 5) to have a fundamental internal structure of knowledge; in addition, one must also know or have established the set of relations between two levels of knowledge (Proposition 5 d), facts or elementary principles on one hand and fundamental principles on the other.

The implication is that the network of relations between the two levels of knowledge constitutes the formal component in a fundamental internal structure of knowledge while the two levels themselves constitute the material components.

Subjectively, a fundamental internal structure of knowledge consists in grasping or understanding the network of relations between the two levels (Proposition 5).

Within the classification schema of definitions, because the statement defines a fundamental internal structure of knowledge in terms of its physical parts--albeit analogically--the definition is a physical definition.

C. What are the Logical Components of a Fundamental Internal Structure of Knowledge?

In this section, one is looking for propositions pertaining to the idea of a fundamental internal structure of knowledge in relation to other cognate ideas. The question could be reformulated as follows: To what class does it belong when compared with other ideas within the same hierarchy of classes or sub-classes? Or, in relation to other cognate

ideas, is a fundamental internal structure of knowledge a genus, a species?

The following proposition of the ninth evolving explanation is pertinent:

Proposition 6: A fundamental internal structure of knowledge is a symbolic system:

- a) which is the result of operations of classification and relationships;
- b) by means of which the learner represents his view of the world;
- c) and with which he then operates on its variants.

For purposes of translation, one can first conjecture, from an analysis of this proposition in terms of how the predicate applies to the idea of a fundamental internal structure of knowledge, that the idea 'system' is a genus; second that the idea 'symbolic' is a qualifier which differentiates the idea of a fundamental structure of knowledge from other members in the genus called 'system'; thirdly, that the ideas 'by means of which the learner represents his view of the world', 'and with which he then operates on its variants', are intended to further differentiate the idea of a fundamental internal structure of knowledge from other members in the same genus.

Complete logical definitions require that the proximate genus (the class) and the differentia specifica (which

differentiates the idea of the pivotal entity from other members in the same class) be stated. The genus is expressed by means of an abstract noun and the differentia specifica by means of a qualifier of that noun. Thus in the statement 'man is a rational animal', the proximate genus is 'animal' and the differentia specifica is 'rational'. But to be able to say so requires a knowledge of the hierarchy of genera and differentiae specifica; thus to state that 'man is a material substance' may be a true statement but it is not a logical definition since 'substance' in the tree of Porphyry is a remote genus and 'material' is a differentia specifica for the species 'bodily beings' and not for 'man'; the same can be said of the statement 'man is an organic body' in which 'body' is a genus and 'organic' is a differentia specifica for the species 'living beings' but not for 'man'. It is obvious that there are remote, intermediate and proximate genera and that unless an idea can be related to the proximate genus and to a differentia which is specific, a logical definition does not ensue.

If one analyzes the nature of the relationships between ideas in Proposition 6, one recognizes that the idea 'system' is a genus to which a fundamental internal structure of knowledge belongs although one does not know whether the genus is proximate, or intermediate, or remote; that the idea 'symbolic' differentiates in some respect the idea of a fundamental

internal structure of knowledge from other members in the genus at the proximate, or intermediate, or remote level; that the ideas 'with which we operate' and 'by means of which we represent the world' are apparently used to further differentiate the idea of a fundamental internal structure of knowledge from other members of the same genus though one does not know if they differentiate at the proximate, or intermediate, or remote levels or beyond.

One can only conclude that the logical components of a fundamental internal structure of knowledge cannot be ascertained from Proposition 6 and that at best the ideas of structure, system, symbolic, etc. are somewhat related.

Within the classification schema of definitions because the proposition attempts to define a fundamental internal structure of knowledge in terms of its logical components, one might say that it is an attempt to give its logical definition.

D. What are the Attributes of a Fundamental Internal Structure of Knowledge?

The attributes of a fundamental internal structure of knowledge describe it in terms not of its essence but in terms of special modifications which are accidental to it.

An attribute modifies a pivotal entity first, in its being quantitatively or qualitatively or related to something else; secondly, in virtue of something outside itself such as

the effect it has on something else, the effect something else has on it, etc.

One is therefore looking for answers to such questions as: What sort of thing is a fundamental internal structure of knowledge? To what is it referred? What does it do to another? What is done to it?, etc.

The following propositions from the ninth evolving list provide answers to the above questions:

Proposition 3: A fundamental internal structure of knowledge is useful in

- a) achieving general transfer, i.e. in recognizing because of its breadth of applicability,
 - that relations between things one encounters now are the same kind of relations between things one encountered earlier,
 - that something is a specific instance of a more general case;
- b) comprehending other things, i.e. it makes other things understandable;
- c) providing for continuity in the expansion and deepening of one's knowledge that is, other things can be generated from structure i.e. other observable characteristics, effects, etc. can be hypothesized;
- d) retaining what has been understood, i.e. it does

not overload the memory capacities and permits reconstruction of details.

Proposition 7: A fundamental internal structure of knowledge as a consequence of its usefulness (general transfer, continuity, retention) is more economical than the knowledge of specific topics and skills.

Proposition 8: A fundamental internal structure of knowledge is:

- a) comprehensible, i.e. it makes other things understandable in terms of other things;
- b) simple, i.e. it is free of complex details;
- c) powerful, i.e. it has the quality of effective applicability to problems and situations;
- d) effective whether the mode of thought is intuitive or analytic; intuitively as when one operates quickly and with facility; analytically as when one operates more systematically and formally;
- e) representable, i.e. it can be embodied in a symbolical mode as in a formula or in a concrete mode as in a model device.

The attributes referred to in the above propositions can be grouped under two main headings; the formal and the functional attributes.

Formal attributes are those which intrinsically describe a fundamental internal structure of knowledge in

terms of its perfection as an entity; the qualities which are attributed to it refer to the determining factor which distinguishes it from all others.

First, a fundamental internal structure of knowledge is simple (Proposition 8) in the sense that it is inherent to the nature of the formal component--the network of relations between two levels of knowledge--to channel many elementary principles toward a fundamental principle which subsumes it so that it is free of complex details.

Second, a fundamental internal structure of knowledge is powerful (Proposition 8) in the sense that it is inherent to the established network of relations between two levels of knowledge to be effective when applied to problems and situations.

Third, a fundamental internal structure of knowledge is externally representable (Proposition 8) in the sense that the network of relations can be embodied in concrete objects or situations, in diagrams, in symbols in its skeletal form.

Fourth, a fundamental internal structure of knowledge is economical (Proposition 7) i.e. it achieves general transfer, continuity and retention much better than other forms of knowledge.

Functional attributes are those which describe a fundamental internal structure of knowledge in terms of its uses or what it does for the learner.

First, a fundamental internal structure of knowledge makes other things related to it more comprehensible (Proposition 8), i.e. as a network of relations much low-level information has been integrated into high-level knowledge; as a consequence many other things are made simpler to understand.

Second, a fundamental internal structure of knowledge aids memory (Proposition 3), because the network of relations carries the terms of the relations--one term, low-level information, and the other term, a fundamental principle--it does not overload one's memory capacities and yet the details can be reconstructed from it.

Third, a fundamental internal structure of knowledge enables one to achieve general transfer (Proposition 3) i.e. to recognize that the network of relations between two levels of knowledge is applicable to a new situation or phenomenon, that it is as an instance of a more general case, that it has the same kind of relationships as something encountered before.

Fourth, a fundamental internal structure of knowledge provides continuity in the expansion and deepening of one's knowledge (Proposition 3), i.e., the network of relations constitutes a focal point from which one can generate hypotheses about other observable characteristics, effects, etc. and a stepping-stone from which one can go on to more fundamental structures or by means of which one can acquire more

knowledge.

Fifth, a fundamental structure of knowledge enables a person familiar with it to operate efficiently 'de facto' in dealing with problems, whether the mode is intuitive or analytic (Proposition 8), i.e. a firm grasp of the network of relations increases the effectiveness of the operation whether just a few cues are used or whether one is systematic in dealing with problems.

In brief, the formal attributes of a fundamental internal structure of knowledge are its simplicity, power, representability, and economy; its functional attributes are its utility in aiding memory, in achieving general transfer, in providing continuity in the expansion and deepening of one's knowledge, in enabling a person to operate effectively when dealing with problems, either intuitively or analytically.

Within the classification schema of definitions because the statements define a fundamental internal structure of knowledge in terms of its attributes, the definition is a descriptive definition.

The question arises as to whether one or more of the attributes are necessary: are they found in all fundamental internal structures of knowledge, always, and in them alone? To answer this question, one either relies on some statement by Bruner or on a conclusion derived from a consideration of

the logical components. Bruner has not addressed himself to this problem in The Process of Education and it is impossible at this point to come to a conclusion from a consideration of the logical components since neither the genus nor the differentia specifica have been ascertained.

E. What are the Effectors of a Fundamental
Internal Structure of Knowledge?

Section B of this section studied the physical components of a fundamental internal structure of knowledge, i.e. the intrinsic physical components on which its existence depends and without which it could not be said to constitute an entity of some kind. Section C studied the logical components i.e. the intrinsic logical factors which place a fundamental internal structure of knowledge in relationship with other ideas.

In this section, the effectors of a fundamental internal structure of knowledge, that is, its agents, the processes involved and the conditions required are studied.

Effectors are found in propositions which answer such questions as: By what kind of process is it acquired? What is required? What principally produces it? What facilitates its development and acquisition?

Propositions 9 and 10 of the ninth evolving list of derived propositions are intended to provide answers to such questions.

Proposition 9: A fundamental internal structure of knowledge is developed intuitively or analytically as a result of the use of concrete or formal operations aided by supportive habits, skills and attitudes in the processes involved in the act of learning:

- a) the intuitive mode yields a tentative and quick ordering of knowledge while the analytic mode orders knowledge more formally and systematically;
- b) operations are internal and reversible actions such as disjunction, inclusion, ordering, etc.;
- c) concrete operations are involved in the structuring of present reality while formal operations are involved in probability structuring; the type of operation used also depends on a person's stage of development;
- d) supportive habits, skills, and attitudes refer to guesses, follow-ups on hunches, problem-solving strategies, connectedness of things, inherent order in nature, confidence in one's ability to discover, etc.
- e) the processes involved in the act of learning are acquisition of knowledge, transformation of this knowledge and evaluation of the transformations.

Proposition 10: A fundamental internal structure of knowledge may be developed through the environment in general and the school environment in particular. In the school environment it is developed by means of:

- a) a spiral curriculum based on the structure of a discipline or subject, built with an eye for continuity and development through episodic units (units which reflect the processes of acquisition, transformation and evaluation) with due regard for the thought forms of the learner, which turns back on itself to revisit basic ideas and leads the learner to the formal apparatus that goes with the learning of fundamental structures;
- b) teaching which translates the structure of a subject in the appropriate thought forms of the learner;
- c) teaching methods such as confrontation with apparently conflicting facts, experiments which force the learner to pay attention to several aspects of a phenomenon, games which highlight basic operations--all under the umbrella of the discovery approach. This approach consists in the finding of regularities of previously unrecognized relations and similarities between ideas through the incorporation of the processes involved in the act of learning in episodic and cyclical units;

- d) searching examinations which emphasize understanding of broad principles and connectedness between specific facts;
- e) teachers who as scholars, communicators, models, personal symbols are the principal aids;
- f) teaching aids such as models, laboratory experiments, demonstrations, sequential programs which embody structures.

The effectors which the above statements mention may be grouped under two main headings: the internal effectors, i.e. the factors related to the internal activity of the learner; and the external effectors, i.e. the factors related to the aids which facilitate the activity of the learner.

The internal effectors are first considered. It is apparent from Proposition 9 that operations guided by the logic of classes and relations and used intuitively or analytically in the processes of the act of learning, are internal effectors of a fundamental internal structure of knowledge. If a fundamental internal structure of knowledge is the network of relations between facts and fundamental principles, between principles and higher principles, it means: that first, the facts or lower principles must be known; that secondly, they must be transformed; that thirdly, the transformations themselves must be evaluated. Each process requires internal reversible actions or operations on the part

of the learner. Guided by the logic of classes, he performs the relational operations of disjunction, inclusion, order, etc.

If the learner is thorough, he verifies his transformations by trying to see their degree of fitness to the original object of knowledge and by checking the very logic of his operations.

At the concrete operational stage of development, the learner's operations for each of the three processes--acquisition, transformation, evaluation--require the presence of objects; at the formal operational stage, the presence of objects is not necessary. Moreover, the learner can operate intuitively or analytically: intuitively by operating using few cues; analytically by using some kind of formal apparatus. The learner who has not yet reached the formal operations stage uses the intuitive mode of thinking mostly; adults may use both, one complementing the other.

Another set of internal effectors is the habits (Proposition 9), skills and attitudes which not only support a constituted fundamental internal structure of knowledge but also contribute to its development. The learner who has the attitude that things are connected, that there is order in the phenomena he examines, that he can discover relationships, that he can guess, that he can follow a hunch, that he can use certain approaches toward solving problems (heuristics),

is more likely to develop and learn a network of relations between two levels of knowledge.

The external effectors can be grouped under the general notion of environment; the school environment is of particular interest.

One of the external effectors related to the school environment is the spiral curriculum; it is a curriculum which is oriented towards the structure of a discipline but which is so constructed that its episodic units incorporate basic ideas and principles and learning processes commensurate with the learner's stage of development and level of knowledge; these basic ideas and principles are revisited later when the learner has reached another stage of development and/or has the background necessary to go beyond the more elementary structures learned en route. As the learner progresses he modifies his structures.

The teacher also is an external effector, instrumental in helping the learner learn structures. Teaching expedites the learning of structures provided the teacher himself understands the structure of his discipline, understands its sequential development in a spiral curriculum, is skilled in helping learners discover the network of relations between different levels of knowledge and in using teaching aids which embody a structure.

It should be noted that external effectors are instrumental effectors only and that the principal effector is the learner who operates.

In brief, efficient factors, labelled effectors in this research may be internal i.e. they originate from within the learner or external, i.e. they originate from outside the learner. The principal effector is the learner himself through operations used in the modes of thinking and supported by skills, habits, and attitudes; the external effectors are the environment in general and the school environment in particular whose special facilitative features are the spiral curriculum and teachers who use methods and aids which encourage discovery.

Within the classification schema of definitions, because some propositions define a fundamental internal structure of knowledge in terms of means and aids (internal and external effectors) used by the learner to effect it, the definitions are 'efficient cause' definitions.

F. What are the Intentions, the Motives of those
Concerned with the Learning of a Fundamental
Internal Structure of Knowledge?

One is concerned here with what moves the principal and instrumental agents to be concerned with the development or learning of structures. Purposes and motives are found in propositions which answer such questions as: What value

does the learner place on the development or learning of structures? Why would he try to acquire them? Why is it deemed important to the learner or to others concerned with his education? What advantages do they see in it?

Propositions 11 and 12 of the ninth evolving list of derived propositions are intended to provide answers to such questions:

Proposition 11: A fundamental internal structure of knowledge is sought by the learner for motives internal and/or external to himself.

- a) The internal motives may be: interest or intellectual excitement, curiosity, lure of discovery, desire for deep and broad knowledge, mastery, intellectual excellence;
- b) the external motives be: grades, approval of others, success in the educational and professional worlds.

Proposition 12: A fundamental internal structure should be learned according to some interested in the educational enterprise because it enables a person through its attributes to use his or her knowledge and because it is valuable in achieving optimum intellectual development (intellectual excellence) i.e. in utilizing fully his or her intellectual powers.

The purposes which the above statements reflect may be grouped under two main headings: the learner's purposes and the educational enterprise's purposes or public purposes.

The learner's purposes are of two kinds: internal and external (Proposition 11). The learner may wish to learn structures simply because he is interested in the material or problem at hand, or because he is curious, or because he likes to discover, or because he wishes to broaden and deepen his knowledge; these are internal motives. Then he may learn structures because he wishes to receive the approval of others, because he desires good grades, because he desires success in the educational and professional worlds; these are external motives.

Another set of purposes refers to those which the educators might have for helping learners develop structures though these purposes might not be perceived by the learners initially. Educators who value the attributes of fundamental internal structures of knowledge i.e. comprehensibility, simplicity, achievement of general transfer, etc., in other words their utility for the learner and who value optimum intellectual achievement, foster teaching which helps the learner develop or learn structures.

Within the classification schema of definitions, because some propositions define a fundamental internal structure of knowledge in terms of the private and public reasons

for which it is produced, these definitions are 'purposive cause' definitions.

2. Integrative Summary

In section 1 of this chapter, the propositions of the ninth evolving list of derived propositions were translated into Patry's classification schema. Section 2 of this chapter purports to present an integrative summary of Bruner's explanation also in terms of Patry's classification schema.

The nominative definitions of a fundamental internal structure of knowledge fall into the category of common nominal definitions. One recognizes, within this category, words which point to what it is not--the negative referents: it is not coverage; it is not the mastery of facts, of techniques or specific skills, of recipes; it is not the use of devices. Other words within this category point to entities which are somewhat like a fundamental internal structure of knowledge: it is somewhat like a general picture, somewhat like a model, somewhat like a pattern, somewhat like a theory, somewhat like a genotype.

The real intrinsic essential definitions of a fundamental internal structure of knowledge are of two types--the physical and the logical. Its physical definition may be expressed thusly: it is a network of relations between two levels of knowledge, one level being facts, or elementary

principles, and the other level fundamental ideas or principles (ideas as rules of operation); the network of relations constitutes its formal component and the two levels of knowledge its material components. Its incomplete logical definition may be expressed thusly: a fundamental internal structure of knowledge is a symbolic system; 'system' is a genus of some kind; 'symbolic', 'with which we operate', 'by means of which one represents the world', are qualifiers which attempt to circumscribe the idea of system but not in a specific way.

The real intrinsic descriptive definitions of a fundamental internal structure of knowledge should also be of two types--definitions in terms of the necessary attributes (property in Patry's classification schema) and definitions in terms of contingent attributes (set of accidents in Patry's classification schema). Because it has not been possible to ascertain whether any of the attributes is necessary (*omni, soli, semper*), no such distinctions are made in reporting the descriptive definitions. However, a distinction can be made between formal and functional attributes. A descriptive definition in terms of the formal attributes may be stated as follows: a fundamental internal structure of knowledge has the formal attributes of simplicity i.e. it is free of a mass of details; of power, i.e., it has the quality of effective applicability to problems and situations; of representability,

i.e., it can be embodied symbolically or concretely; of economy, i.e. general transfer, continuity and retention are better achieved with it than with knowledge of specific facts, techniques, etc. A descriptive definition in terms of its functional attributes may be stated thusly: a fundamental internal structure of knowledge makes other things related to it more comprehensible, aids memory, enables the learner to achieve general transfer, provides continuity in the expansion and deepening of one's knowledge, enables a person to operate effectively in dealing with problems whether the mode is intuitive or analytic.

The real extrinsic definitions of a fundamental internal structure of knowledge also fall within two categories --definitions which state the agents and those which state the purposes of agents. Definitions which state the agents are of two types--the definitions which refer to the principal agent(s) and those which refer to the instrumental agent(s). In this research, because of the nature of the pivotal entity, it was necessary to be more specific about the action of the agents as explained by Bruner. Thus to define a fundamental internal structure of knowledge by its principal agent one would have to say that it is effected internally by the learner by means of operations--concrete and/or formal, depending on the stage of development--guided by the logic of classes and relations and by means of habits,

skills, and attitudes such as those of guessing, of following a hunch, of problem-solving, of using heuristics of the connectedness of things, etc.; to define a fundamental internal structure of knowledge by its instrumental agents, one would have to say that the learner is helped externally in his efforts to construct and develop fundamental structures by the environment in general and the school environment in particular through the use of a spiral curriculum by teachers who are scholars, communicators, models, personal symbols and skilled in expediting learning by means of methods and aids which encourage discovery.

Real extrinsic definitions which state the purposes of the agents are also of two types--definitions which refer to the purposes of the principal agent and definitions which refer to the purposes of the main instrumental agent. A definition of a fundamental internal structure of knowledge which refers to the purposes of the principal agent may be stated thusly: it is that which depends for its existence on the learner's internal motives such as his interest in and desire for deepening and broadening of his knowledge, his perception of the utility of knowledge and/or his external motives such as approval of peers, parents, teachers, grades, success. A definition which refers to the purposes of the main instrumental agents may be stated thusly: it is that which depends for its existence on the purposes of those

responsible for the learner's education, such as its utility for the learner in aiding his memory, in achieving general transfer, etc., in brief, in achieving optimum intellectual development.

It must be noted that while there are many purposes for which a fundamental internal structure of knowledge could be developed, Bruner strongly emphasizes that the learner's internal motives are the important ones.

As an overview, Bruner's explanation of a fundamental internal structure of knowledge as translated and integrated is presented in schematic form in the Appendix.

CHAPTER XI

APPRAISAL OF BRUNER'S EXPLANATIONS

The integrative summary of the explanation of a fundamental internal structure of knowledge is the culmination of the application of the processes of selecting and analyzing pertinent attributors, of deriving meaningful propositions from them, of translating these propositions into a schema of definitions, and of integrating the definitions into a whole.

The final task is that of assessing the explanations qua explanations of a fundamental internal structure of knowledge, i.e. Bruner's explanation as presented and Bruner's explanation as translated and integrated. The quality of the explanations can be assessed on the basis of their degree of clarity of expression and meaning.

The chapter is divided into seven sections with the following headings: from peripheral attributors to nominal definitions, from essential and denotative attributors to a physical definition, from essential attributors to a logical definition, from descriptive attributors to descriptive definitions, from agentive attributors to an effector definition, from purposive attributors to purposive definitions; the last section is a general appraisal of Bruner's explanations.

1. From Peripheral Attributors to Nominal Definitions

The intent of a communication may be to help the receiver to indirectly identify a pivotal entity akin to other entities or different from them in some respect.

Clarity here requires that the words which represent the entities and serve as intermediaries be better known to the reader or that their meaning be easily acquired by reference to the dictionary; furthermore, the entities to which these words refer must themselves be better known.

A. Explanation as Presented by Bruner

The terms coverage, facts, techniques, specific topics and skills, devices, recipes¹ explicitly or implicitly accompanied by the negation adverb 'not' are sufficiently clear to indicate to the reader what a fundamental internal structure of knowledge is not.

With respect to the positive terms, however, such as general picture, model, pattern, theory, genotype,² it is not enough to suggest as in the following example, that "if earlier learning is to render later learning easier, it must do so by providing a general picture in terms of which the

1 Jerome S. Bruner, The Process of Education, Cambridge, Harvard University Press, 1960, p. 2, 12, 31, 39.

2 Ibid., p. 8. 12, 24-25, 81.

relations between things encountered earlier and later are made as clear as possible". With such a complex entity as a fundamental internal structure of knowledge, it is reasonable for the reader to expect Bruner to show in more detail the similarities and differences of the entities as given in the examples in relation to structure; this was not done.

B. Explanation as Translated and Integrated

As part of the explanation as translated and integrated, the nominative definition which states that a fundamental internal structure of knowledge is somewhat like a general picture, somewhat like a model, somewhat like a pattern, somewhat like a theory, somewhat like a genotype is clearer than the peripheral attributors as part of the explanation as presented. This is due partly to the fact that one goes beyond the words to the entities they represent and attends to their common features, partly to the introduction of the vague qualifier 'somewhat' which telegraphs to the reader that structure and the other entities in the definition are not the same though they are similar in some respects. Thus one is made aware of the relative importance of the communication to convey meaning.

'In toto', Bruner's explanation as presented concerning entities which are different from or somewhat like structure leaves something to be desired; clearer understanding

results once the attributors have been analyzed and the findings translated and integrated.

2. From Essential and Denotative Attributors
to a Physical Definition

The intent of a communication may be to help the reader to get to the heart of the matter; in other words, the author of the communication is more concerned in conveying to the reader what the pivotal entity is than what it is not or what it is like. Clarity requires that the essential components--the physical and the logical--be identified. In this section, the explanations of the physical components are examined.

A. Explanation as Presented by Bruner

There are several difficulties in the explanation as presented by Bruner. First, confusion is introduced in the reader's mind by the appositional use of the terms principles,³ ideas,⁴ and attitudes.⁵ The reader vacillates between understanding structure as the same kind of entity as principles, ideas, and attitudes and as a completely different kind of entity, between understanding these entities as the whole of structure and as part of structure.

3 Ibid., p. 25-26, 31.

4 Ibid., p. 3, 81, 82.

5 Ibid., p. 17, 20.

Second, the idea that facts are not the same thing as structure comes out clearly though their relationship to structure does not.⁶

Third, though the idea of relations is a recurrent theme in The Process of Education, the reader is again confused by the appositional use of terms like connectedness, meaning, significance,⁷ relatedness, order, and general case.

Fourth, the examples Bruner gives to define structure⁸ do not convey a clear idea of the components of structure. The explanation Bruner gives of each example do not sufficiently point to its constituent parts. One legitimately expects clear references to the invariants of structure of which each example is an instance.

B. Explanation as Translated and Integrated

An identification of the physical components of structure emerged from an analysis of the examples; the two orders of knowledge constitute the material components and the network of relations between them, the formal component. In addition a comparison of the examples lead to a distinction between fundamental and elementary structures; the

6 Ibid., p. 21-32, 48-50.

7 Ibid., p. 6-7, 12, 17, 19, 31-32, 47, 60.

8 Ibid., p. 6-8.

components of a fundamental structure are of a higher order than those of an elementary structure; yet there is continuity between the two since elementary structures may constitute the base (a material component) for fundamental structures. Subjectively, a fundamental structure consists in the apprehension by the learner of the network of relations between two higher orders of knowledge; it is in that sense that it is internal.

The conclusion was that a fundamental internal structure of knowledge consists in the grasping of the network of relations between two levels of knowledge.

In brief, Bruner's explanation of the physical components of a fundamental internal structure of knowledge as presented in The Process of Education is vague and ambiguous; there are too many meanings for one word and too many words for one meaning.

Much analysis is necessary to identify the physical components of a fundamental internal structure of knowledge.

3. From Essential Attributors to a Logical Definition

Another way of conveying meaning about a pivotal entity is to say what it is by relating the idea one has of it to others in the same general class and by identifying its specific difference. The author of a communication concerned with this aspect would therefore clearly identify the general

class to which the idea of a pivotal entity belongs and explain why it belongs to it; in addition, he would state the specific difference between it and other members in the same class. In other words, the communicator is attempting to convey the logical components--the genus and the differentia specifica.

A. Explanation as Presented by Bruner

Bruner refers to internal structures as "symbolic systems"⁹ which can be interpreted by the reader as an attempt to state the class to which they belong--'system'--and at the same time to show how they differ from other members in the same class.

But Bruner uses the words 'symbolic systems' without further comments. One would have liked to have a clearer explanation as to how and why a structure is a symbolic system. Bruner did not go beyond mentioning the words; as a result, the reader is left with the task of finding out how his concept of system--which might not be the same as Bruner's--fits the concept of structure. Moreover, even if the reader's concept of system should match that of Bruner's, he cannot identify the specific difference between structure and other members of the same class; Bruner qualifies the word 'system'

⁹ Ibid., p. 37.

with the adjective 'symbolic' but does not explain how this is so.

The examples that he gives--how the child's view of angles of reflection and incidence changes in time, and how the child's view of the principles involved in the balance scale is constructed--while they might be exemplars of a symbolic system, are not explicitated in point by point matching to what constitutes a symbolic system.

As a consequence, the reader cannot see how the idea of structure is related to the idea of symbolic system.

B. Explanation as Translated and Integrated

It was not possible to elucidate greatly what would be construed as a logical definition from an analysis of the attributor as found in The Process of Education. The idea of system emerges as a genus but one is unable to state whether the genus is proximate, intermediate or remote; the idea 'symbolic' emerges as a difference but one is unable to say whether the difference is at the proximate (specific), intermediate or remote levels; other qualifiers 'with which we operate', 'by means of which we represent the world' do not appear to be specific to symbolic systems.

A better explanation therefore does not result from tighter analysis; rather, the gaps are even more obvious.

In short, with respect to the logical components of a fundamental internal structure of knowledge neither Bruner's explanation as presented nor Bruner's explanation as translated and integrated is clear.

4. From Descriptive Attributors to Descriptive Definitions

If the author of a communication wishes to convey clear meaning concerning the qualities or attributes of a pivotal entity, he must not only identify and explain them but differentiate between those which are necessary, i.e. found in all pivotal entities, always, and in them alone, and those which are contingent, i.e. which do not meet these criteria.

A. Explanation as Presented by Bruner

First, in several parts of his communication, Bruner identifies the attributes of a fundamental internal structure of knowledge, though often indirectly and in conjunction with something else.

Thus, when he states that there "are at least four general claims that can be made for teaching the fundamental structure of a subject"¹⁰ and correlates this with 'understanding',¹¹ on the part of the learner, it is clear that he

10 Ibid., p. 23.

11 Ibid., p. 23.

communicates to the reader the idea that a fundamental internal structure of knowledge helps the learner to make things comprehensible,¹² aids memory,¹³ provides for general transfer,¹⁴ and bridges the gap between elementary and advanced knowledge.¹⁵

Other attributes are identified in the course of discussing some other aspects. Thus, one finds references to economy,¹⁶ to effectiveness in the intuitive and analytic modes of thinking,¹⁷ to simplicity,¹⁸ to power,¹⁹ to representability,²⁰ of a fundamental internal structure of knowledge.

Second, Bruner often explicates the attributes he has identified by means of simpler statements and/or illustrations and/or examples. But Bruner's explanations

12 Ibid., p. 23.

13 Ibid., p. 24.

14 Ibid., p. 25.

15 Ibid., p. 26.

16 Ibid., p. 31.

17 Ibid., p. 62, 63.

18 Ibid., p. 12-13.

19 Ibid., p. 12-13, 18, 33.

20 Ibid., p. 25.

concerning the attributes of transfer,²¹ aid to memory,²² facilitation of intuitive thinking,²³ effectiveness in intuitive and analytic thinking,²⁴ representability,²⁵ economy,²⁶ communicate more meaning than his statements concerning the attributes of simplicity²⁷ and power.²⁸ Also, Bruner's illustrations and examples concerning the attributes of aid to memory,²⁹ facilitation of intuitive thinking,³⁰ representability,³¹ result in better understanding than his illustrations and examples for the attributes of comprehensibility³² and transfer.³³

21 Ibid., p. 5-6, 17, 24.

22 Ibid., p. 31.

23 Ibid., p. 62.

24 Ibid., p. 59.

25 Ibid., p. 25, 81-82.

26 Ibid., p. 31.

27 Ibid., p. 13.

28 Ibid., p. 13, 18, 33.

29 Ibid., p. 24-25.

30 Ibid., p. 62.

31 Ibid., p. 25.

32 Ibid., p. 23-24.

33 Ibid., p. 24.

B. Explanation as Translated and Integrated

Four observations are in order. First, the identity of the attributes appears more clearly in the explanation as translated and integrated.

Second, the distinction made between formal and functional attributes, i.e. those which are related to the nature of a fundamental internal structure of knowledge and those which refer to its utility for the learner clarifies the issue. It is not clear however how the formal and functional attributes are related to each other e.g. is it an aid to memory because it is simple or because it is powerful, or both?

Third, the necessary attributes are not distinguished from the contingent attributes. It could not be ascertained whether there is (are) any attribute(s) which apply to all fundamental internal structures of knowledge, to them only, and always.

Fourth, the list of attributes, each one followed with a short interpretation of its meaning, expresses the gist of Bruner's communication though one would have to refer to the text itself for more complete understanding.

In general, Bruner's explanation as translated and integrated of the attributes of a fundamental internal structure of knowledge is clearer than his explanation as presented, though a few questions concerning the nature of their

relationship to structure and their interrelationships are left unanswered.

5. From Agentive Attributors to 'Effector' Definitions

The author of a communication may intend to convey meaning about a pivotal entity by explaining that upon which it extrinsically depends for its existence. The clarity of the communication requires that the purposes and the agents be identified.

An appraisal of the explanations concerning the agents is dealt with in this section and that concerning the purposes in section 6. It is deemed necessary, however, to precede these appraisals with a few remarks.

First, the reader of The Process of Education soon senses that one of the chief aims of the publication is to promote the teaching and learning of structures. From the first two chapters, it is quite obvious that Bruner is convinced of the importance of teaching and learning of structures--the why question--and of the manner of teaching and learning them--the how question. But the reader is soon subtly invited to a consideration of learning in general with only sporadic specific references to structure in the other four chapters: four references in Chapter 3 on Readiness

for Learning,³⁴ three in Chapter 4 on Intuitive and Analytic Thinking,³⁵ none in Chapter 5 on Motives for Learning, three in Chapter 6 on Aids to Teaching.³⁶

Second, the reader must assume that what applies to learning in general applies to the learning of structures in particular or that learning is to be equated with the learning of structure.

Third, even with that assumption, the reader who does not have a clear idea of the nature of a fundamental internal structure of knowledge and its relationship to ideas, principles, representations, concepts, rules, operations is at a loss to appreciate fully its purposes and to understand the factors which produce it or are conducive to its learning.

The appraisals in sections 5 and 6 of Bruner's explanations concerning the purposes and agents of a fundamental internal structure of knowledge are therefore based on the plausibility of the assumption stated above. The appraisal which follows concerns the purposes.

A. Explanation as Presented by Bruner

It is apparent from his communication that Bruner recognizes several agents to the learning of fundamental

34 Ibid., p. 33, 36-37, 48, 51.

35 Ibid., p. 58, 60, 62.

36 Ibid., p. 81, 82, 84.

internal structures. There is of course the learner himself whose intellectual development³⁷ is traced in the light of Piaget's theory and which differentiates several stages according to the kind of intellectual means--actions and/or operations--the learner has at his command to manipulate reality and to construct his views of the world. Bruner does communicate the idea that the learning of fundamental internal structures of knowledge is possible only³⁸ at the concrete operational and formal operational stages but the reader must be attentive to Bruner's statement that "concrete operations [...] are means for structuring only immediately present reality",³⁹ and relate it to other statements like "each way of looking at the phenomenon represents the result of an operation",⁴⁰ "an operation is a means of getting data about the real world into the mind and there transforming them so that they can be organized and used selectively in the solution of problems".⁴¹ Neither is the relationship between the last statement and the statement that "transformation comprises the ways we deal with information

37 Ibid., p. 33-48.

38 Ibid., p. 35.

39 Ibid., p. 37.

40 Ibid., p. 36.

41 Ibid., p. 35.

to go beyond it"⁴² immediately evident.

The processes involved in the act of learning⁴³--acquisition of knowledge, transformation and evaluation--are well explained but again here one would have expected that their relationships to structure would have been stated more explicitly.

The same lack of clarity applies to Bruner's discussion of the intuitive and analytic modes of thinking and their relationship to structure. Thus he states that "intuition by itself yields a tentative ordering of a body of knowledge"⁴⁴ but does not describe how this is accomplished. Even at that, the reader must relate "ordering of knowledge" and "structure" through the statement that "intuition implies the act of grasping the meaning, significance or structure of a problem".⁴⁵

With respect to the internal conditions propitious to learning structures, there are many references scattered throughout Bruner's communication to habits, skills and attitudes⁴⁶ which facilitate the learning of structures but

42 Ibid., p. 48.

43 Ibid., p. 48.

44 Ibid., p. 60.

45 Ibid., p. 60.

46 Ibid., p. 12, 13, 14, 18, 27, 29, 63, 64, 65.

there are also references to heuristics, to guessing, to hunches, to traits of personality⁴⁷ which facilitate learning in general in which case the reader must again assume that what applies to learning generally applies to the learning of structures. The communication requires that the reader concatenate such statements as: "there are certain general attitudes or approaches toward science or literature that [...] would leave considerable relevance for later learning. The attitude that things are connected is a case in point",⁴⁸ "In mathematics, this subject has a formal name, 'heuristic', to describe the approach one takes to solving problems",⁴⁹ "it is difficult to believe that general heuristic rules--the use of analogy, the appeal to symmetry, the examination of limiting conditions, the visualization of the solution--when they have been used frequently will be anything but a support to intuitive thinking",⁵⁰ "that intuition by itself yields a tentative ordering of knowledge"⁵¹ or structure. The same applies to other attitudes and approaches as guesses, self-confidence, courage, hunches.

47 Ibid., p. 13, 4, 64, 65, 73.

48 Ibid., p. 27.

49 Ibid., p. 27.

50 Ibid., p. 64.

51 Ibid., p. 60.

The external conditions conducive to learning of structures are well communicated. The reader is made aware of the importance of the spiral curriculum⁵² in all fields,⁵³ organized in episodic units⁵⁴ around the fundamental structure of a discipline⁵⁵ and with due regard for the thought forms of the child.⁵⁶ He is also made aware of the role of the teacher: in tailoring fundamental knowledge to the interests, capacities and needs of children;⁵⁷ in presenting phenomena in a way that is exciting, correct and rewardingly comprehensible;⁵⁸ in instilling a sense of excitement about discovery;⁵⁹ in presenting fundamental structures⁶⁰ in terms of the child's way of viewing things;⁶¹ in leading the student through appropriate questions⁶² to shrewd guesses,⁶³

52 Ibid., p. 13, 51-54.

53 Ibid., p. 10 ff.

54 Ibid., p. 49.

55 Ibid., p. 6 ff.

56 Ibid., p. 33, 37, 52-53.

57 Ibid., p. 22, 49.

58 Ibid., p. 22.

59 Ibid., p. 20-22, 51.

60 Ibid., p. 3, 11, 12, 20, 40, 46, 81.

61 Ibid., p. 33, 39, 40, 46-47, 52-54.

62 Ibid., p. 40.

63 Ibid., p. 64-65.

fertile hypothesis, courageous leaps to a tentative conclusion,⁶⁴ to intuitive thinking,⁶⁵ to the use of heuristics;⁶⁶ in helping students to the full utilization of his intellectual powers;⁶⁷ in arousing interest and curiosity;⁶⁸ in training the child concretely and intuitively in logical operations;⁶⁹ in developing an appropriate set of intellectual attitudes and values.⁷⁰

Numerous examples are used to illustrate the above: in social studies,⁷¹ in biology,⁷² in literature,⁷³ in mathematics,⁷⁴ in science,⁷⁵ in language.⁷⁶

64 Ibid., p. 14.

65 Ibid., p. 68, 90.

66 Ibid., p. 29.

67 Ibid., p. 10, 50, 54.

68 Ibid., p. 14, 50, 72, 73.

69 Ibid., p. 34 ff, 47, 89.

70 Ibid., p. 73.

71 Ibid., p. 19, 21, 23, 25, 50-51.

72 Ibid., p. 6-7, 28, 49.

73 Ibid., p. 13, 24, 46-47, 52.

74 Ibid., p. 7, 13, 19, 21, 38, 40, 47.

75 Ibid., p. 12, 22-24, 54.

76 Ibid., p. 8.

It is unfortunate for the reader that Bruner does not go beyond a description of the situations to their analysis in terms of the relationships to what constitutes internal structures.

As for the effectiveness of the teacher as a communicator, as a model and as a personal symbol,⁷⁷ Bruner suggests that it is predicated on the teacher's mastery of the subject matter; the alert reader must translate this to mean mastery of the fundamental structure and not mastery of facts, of programme units, of textbook matter.

B. Explanation as Translated and Integrated

In general, the same general assumption that the reader has to make, namely, that the processes involved in learning generally are really processes involved in learning structures, had to be made. Further distinctions within the agents category also had to be made in order to clearly identify the role of each in learning structures.

The 'agents' category was therefore divided into principal and instrumental agents to clearly indicate that the learner is the principal effector of his own learning of structures and that all other effectors though they may facilitate it are external and will not produce them.

⁷⁷ Ibid., p. 88-90.

Further it was shown that the learner as principal effector operates internally guided by the logic of classes and relations and supported by clearly identified habits, skills, and attitudes. The external effectors--the instrumental agents--are grouped under two major categories, the environment in general and the school environment in particular. The elements that comprise the school environment were identified as the spiral curriculum, the teacher, the teaching methods, and the teaching aids. Finally, each element of the school environment was further ramified and explained.

In comparison with the explanation of the agents of a fundamental internal structure of knowledge as presented in The Process of Education, the explanation as translated and integrated stands out. This is due mainly to making an initial assumption concerning learning and the learning of structures, to focussing on the pivotal entity and to grouping the scattered information concerning the effectors as much as it could be done. All vagueness and ambiguity have not been eliminated, however, precisely because the relationships to structure are based on an assumption.

6. From Purposive Attributors to a Purposive Definition

As stated in section 5, the appraisal of Bruner's explanations as presented and as translated and integrated concerning the purposes is based on the plausibility of the

assumption that what applies to learning in general applies to the learning of structures in particular.

A. Explanation as Presented by Bruner

Bruner identifies the following purposes: interest in the full utilization of one's intellectual powers (the pursuit of excellence),⁷⁸ in knowledge about the world⁷⁹ and the materials at hand,⁸⁰ in the deepening of one's knowledge,⁸¹ in the sense of discovery,⁸² in approval of parents, peers, teachers,⁸³ in the consequences of learning structures such as competitive advantage,⁸⁴ good grades, etc.,⁸⁵ in the utility of structures to make things comprehensible to aid memory, to provide for general transfer, to bridge the gap between elementary and advanced knowledge.⁸⁶

78 Ibid., p. 9, 70.

79 Ibid., p. 72.

80 Ibid., p. 14, 73.

81 Ibid., p. 71, 72.

82 Ibid., p. 73.

83 Ibid., p. 72, 75.

84 Ibid., p. 14, 80.

85 Ibid., p. 14, 70, 76.

86 Ibid., p. 23-26.

It is also quite clear that Bruner places the emphasis on internal rather than on external motives.⁸⁷

B. Explanation as Translated and Integrated

The purposes of learning structures stand out more clearly in the explanation as translated and integrated. A distinction was made between the learner's and the educational enterprise's purposes.

The learner's purposes were grouped under two main headings: those originating from within the learner which are the most commendable (interest, curiosity, lure of discovery, etc.); those originating from without (grades, job success, etc.). The pursuit of excellence or optimum intellectual development and the perceived utility for the learner were identified as public purposes for fostering the learning of structures.

In brief, while Bruner's explanation of the purposes as presented is clear in the specifics, Bruner's explanation as translated and integrated groups the purposes and permits one to perceive them as a whole.

87 Ibid., p. 14ff, 20, 22, 31, 49 ff, 72.

7. General Appraisal of Bruner's Explanations

At the beginning of this chapter, the statement was made that the quality of the explanations could be assessed on the basis of clarity of expression and meaning. An application of this criterion to Bruner's explanations of a fundamental internal structure of knowledge permits one to conclude that the explanation as presented is not as clear as his explanation as translated and integrated.

Even Bruner's explanation as translated and integrated leaves something to be desired but perhaps it helps one to identify the gaps of Bruner's explanation as presented in The Process of Education.

Concerning Bruner's explanation, one can express the regret that: the differences, similarities and relationships amongst principles, ideas and structure are not clearly evident; the differences, similarities and relationships between external and internal structures, between elementary and fundamental structures, between elementary and fundamental principles, between facts and fundamental principles are summarily or inadequately dealt with, if at all; the specific relationship of the act of learning to the development of internal structures is not more clearly stated; the relationships of the concepts of system and symbolic to internal structures is not explored; the process of developing fundamental internal

structures from facts and elementary structures is not clearly explicitated; the description of the attributes of a fundamental internal structure of knowledge are not more closely related to what constitutes it; the method of discovery is not clearly described in terms of its relation to what constitutes a structure; the role of structures with respect to values other than intellectual is not touched upon.

On the other hand, one must remember that The Process of Education is the report of the chairman of the Woods Hole Conference and that while the conference touched on many aspects of learning it could not explore them in depth. Moreover, Bruner as the writer of the report no doubt assumed that the reader had some knowledge of the curriculum endeavours of the time and of the controversies surrounding readiness, maturation, motivation, teaching, learning theories, teaching aids, etc. The chairman's report merely reflects this state of affairs. Viewed in this perspective, the lack of a clear explanation of a fundamental internal structure of knowledge is almost excusable. The Process of Education suggested, regardless, an approach to teaching and learning which was sufficiently novel to arouse the interest of scholars and educators alike which was perhaps all that Bruner had in mind.

SUMMARY AND SUGGESTIONS FOR FURTHER RESEARCH

A review of some of the comments made on Bruner's proposal in The Process of Education that curriculum be designed so as to emphasize the structure of a discipline led to the statement that his concept of structure itself was in need of a definition.

Yet much of what Bruner communicated directly or indirectly in this publication referred more to internal structures than to the concept of structure 'per se'. Consequently, this research was a preliminary effort to clarify Bruner's concept of structure through the study of an extension of that concept, namely, a fundamental internal structure of knowledge.

The problem was reformulated thusly: What integrated explanation of Bruner's concept of a fundamental internal structure of knowledge results from an analysis of Bruner's explanation as presented in The Process of Education? Is this explanation clearer than Bruner's explanation as presented?

Patry's classification schema of definitions was used as a frame of reference and a methodology was developed based on the implications of the nature of the relationships between language and thought, between language and reality. The equivalence of ontological and linguistic categories led to a recognition of 'linguistic units intended to convey meaning

of a particular aspect of a structure of knowledge', i.e. attributors, as data to be analyzed. These attributors constitute Bruner's explanation as presented.

In the second part of this research, the different types of attributors were analyzed and the findings were incorporated into an evolving list of derived propositions.

In the third part, the final list of derived propositions was translated and integrated into the classification schema of definitions; this explanation was then compared to Bruner's explanation as presented.

The conclusion was that though Bruner's explanation as translated and integrated was clearer than Bruner's explanation as presented, there were still several points in need of clarification. The criticisms made by other scholars of his concept of structure are therefore at least partly justified. Bruner might have had an intuitive knowledge of a fundamental internal structure of knowledge but he did not fully communicate this knowledge in The Process of Education.

As such, Bruner's explanation as translated and integrated could serve as a guide to an understanding of The Process of Education and as a hypothesis to be checked and verified in his other publications.

The techniques used in this research to select and group the attributors, to analyze and interpret them, to translate and integrate the results need to be improved and

refined; theoretical linguistics, modern logic, and communications theory are sources that should be explored.

Other conceptual approaches and techniques could also contribute to an explicitation of Bruner's concept. For instance, content analysis techniques could be used and the results compared with those obtained in this research. Also, the concept could be studied in the light of the systems approach; such a study would consider the interrelationships among the elements, the transformation processes and the feedback mechanisms. Bruner's concept of structure could also be compared to that of others who have attempted to define it or to circumscribe it.

Such studies could eventually yield a helpful theoretical framework from which meaningful experimental hypotheses could be generated concerning the concept itself or its applications.

This research is offered as a modest contribution to this endeavour.

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The author gives an account of contemporary methods of thought which he groups under four main headings: the phenomenological, the semiotic, the axiomatic, and the reductive. The chapter on axiomatic methods was useful for this research.

Bruner, Jerome S., The Process of Education, Cambridge, Harvard University Press, 1960, xvi-97 p.

This publication, the object of this research, is also known as the Woods Hole Conference Report. It was written by the Chairman of the conference, Jerome S. Bruner; it is "perforce a selective account of what in his view were the major themes, the principal conjectures, and the most striking tentative conclusions reached. In a proper sense it is the Chairman who is principally responsible [...], however much he made every effort to reflect the thought of his colleagues." (Preface, p. xii). It was on that basis that the contents of the report were ascribed to Bruner.

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This is a sympathetic internal criticism of the linguistic analysis movement in philosophy. The conclusion was useful for the development of the theoretical dimension of the methodology.

Lonergan, Bernard J. F., Method in Theology, New York, Herder and Herder, 1972, xii-405 p.

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APPENDIX 1

INTEGRATIVE SUMMARY OF THE ANALYSIS OF BRUNER'S EXPLANATION OF A FUNDAMENTAL INTERNAL STRUCTURE OF KNOWLEDGE

Patry's classification schema of definitions

Bruner's explanation as translated

Nominal	Etymological Common Synonymical	Negative: It is not only the knowledge of facts, of techniques, of specific topics and skills, of devices, of recipes; facts express the connectedness of things; knowledge of facts must be understood in the context of structure; specific topics and skills must be understood in the context of structure; devices and recipes are often applied without understanding their significance or connectedness.	Positive: it is somewhat like	- a general picture: it permits recognition of regularity of relations between things one encounters now as the same kind of relations between things one encountered earlier; - a model, a theory, a pattern: it is instrumental in understanding other things; - a model: it is instrumental in generating other things from it; - a pattern, a theory: it helps to retain what has been understood; - a genotype: it implies that one has sensed high-level information behind low-level information.
Intrinsic	Essential	Physical	Material component: two levels of knowledge	facts and fundamental ideas or principles (ideas as rules of operation) or elementary and fundamental ideas or principles (ideas as rules of operation)
		Logical	Formal component: the network of relations between two levels of knowledge	
	Descriptive	Set of accidents Property	Genus: It is a system. Merote, intermediate, proximate genus? Differentiae: symbolic, with which we operate, by means of which we represent the world; Differentia specifica:?	
			Formal	- It is simple, i.e. free of complex details. - It is powerful, i.e. it has the quality of effectiveness when applied to problems and situations. - It is representable, i.e. it can be embodied symbolically or concretely. - It is economical, i.e. it achieves general transfer, continuity and retention better than specifics.
Real	Agents	Principal agent the learner (internal effectors)	Functional	- It makes other things comprehensible, i.e. more understandable. - It aids memory, i.e. the memory capacities are not overloaded and the details can be reconstructed from it. - It enables one to achieve general transfer, i.e. to recognize that the network of relations between two levels of knowledge is applicable to a new situation or phenomenon, that it is an instance of a more general case, that it has the same kind of relationships as something encountered before. - It provides for continuity in the expansion and deepening of one's knowledge i.e. it is a focal point from which one can generate hypotheses and a stepping-stone to go beyond it. - It enables a person familiar with it to operate effectively 'de facto' whether the mode is intuitive or analytic: intuitively as when one operates quickly and with facility; analytically as when one operates systematically and formally.
			In general: the learner effects a fundamental internal structure of knowledge by means of operations which are used with the processes involved in the act of learning, according to a certain mode of thought and under certain conditions.	
	Extrinsic	Instrumental agents (external effectors)	In particular	- Operations: Internal and reversible actions guided by the logic of classes and relations such as disjunction, inclusion, ordering, etc. - evaluation of the transformation - Modes: - Intuitive: quick and easy ordering of knowledge - Analytic: systematic and formal ordering of knowledge - Conditions: - Habits, skills, attitudes, such as those of guessing, of following hunches, of heuristics, of connectedness of things, of confidence in one's ability - Concrete and/or formal stages of development
			Environment in general	- Spiral curriculum: Based on the structure of a discipline, built with an eye for continuity and development through episodic units with due regard for the thought forms of the learner, which turns back on itself to revisit basic ideas and leads the learner to the formal apparatus that goes with the learning of structures. - Teaching task: Translating the structure into the appropriate thought forms of the child. - General approach: discovery, i.e. the finding of regularities and similarities - Teaching methods: - Confrontation - Challenging experiments - Games - Searching examinations - Etc.

APPENDIX 2

ABSTRACT OF

A Definitional Study of J. S. Bruner's Explanation of a Fundamental Internal Structure of Knowledge in the Process of Education¹

The purpose of this study was to find a partial answer to the following problem expressed in the form of a question: Would Bruner's explanation of a structure of knowledge obtained through systematic analysis be clearer than his explanation as presented in The Process of Education? Further consideration led to a delimitation and reformulation of this question as follows: Would Bruner's explanation of a fundamental internal structure of knowledge obtained through systematic analysis be clearer than his explanation as presented in The Process of Education?

Part I of the study gives the background to the problem, delineates the problem, describes the conceptual framework and develops the methodology and techniques used. A classic conceptual framework--the aristotelian classification schema of definitions--was used as a guide to translate and to integrate the findings. The methodology was based on the relationships between language and thought, between language

¹ Roland Piché, doctoral thesis presented to the Faculty of Education of the University of Ottawa, Canada, 1974, xii-265 p.

and reality. Attributors, i.e. the linguistic formulations which reflected Bruner's intent to convey meaning about some aspect of a fundamental internal structure of knowledge constituted the data to be analyzed.

In Part II of the study, six sets of attributors--labelled peripheral, essential, denotative, descriptive, agentive, and purposive--were analyzed and the findings were cumulated in the form of a list of derived propositions.

In Part III, the list of derived propositions was translated into the classification schema of definitions to yield an explanation which differentiated the ways of knowing something about the nature of a fundamental internal structure of knowledge. This explanation was compared from the point of view of clarity to Bruner's explanation as presented.

The conclusion was reached that the explanation as translated and integrated was clearer than the explanation as presented but that several points needed further clarification.

It was therefore suggested that the explanation as translated and integrated be used as a hypothesis for further research on Bruner's concept of a fundamental internal structure of knowledge in his other publications. Suggestions for other types of research on Bruner's concept are also given.