INTRODUCTION

This is a how-to-do book. In it I shall present the methods of building theory. But the methods will not be bound to mindless routine, rather to intelligent usage. By setting forth the methods in the context of the logic of theoretical knowledge, understanding of the methods will be emphasized throughout.

One does not build theory from scratch, for theorizing has been going on at least since the time of Socrates. That means, of course, that theorizing was going on before 470 B.C., the probable birth date of Socrates. Theory is built upon extant theory. Consequently, to build theory one must be able to criticize theory. One must be able to achieve an understanding of extant theory and to judge what needs to be done, if anything, to the theory. Only then is one in a position to make constructive moves.

To be able to achieve an understanding of extant theory is to be able to describe and interpret it. When one is able to give such a detailed account of theory, one is able to explicate it. To be able to judge what needs to be done about extant theory is to be able to evaluate it. Evaluation is the process of bringing standards to bear upon something so that it can be judged thereby. Criticism, therefore, consists of explication and evaluation. Perhaps because the culmination of criticism is this act of discernment ('criticism' arises from the Greek 'krisis,' meaning to discern) evaluation, the standards for judgment are called 'criteria'.

Constructive moves with respect to theory are moves to do what is needed. What can be needed is either correction or addition. Construction, therefore, consists of emendation and extension.

In the light of the above exposition, there are four sets of methods involved in building theory. These methods are the two sets of criticism: explication and evaluation, and the two of construction: emendation and extension. Schema 1, on the next page, summarizes this.

5. EMENDING AND EXTENDING THEORY

In concluding this introduction, let me comment on my objective in writing this book. For approximately a quarter of a century, I have been teaching the methods of theorizing, particularity to those students interested primarily in theory of the human educative process. Some of the students wanted themselves to construct theory, but most wanted to be in a position to be intelligent consumers of theory. They wanted to use the best of theory in their lives. To these students' wants, my teaching of the methodology of theory building was and is dedicated. The same dedication is to be found in my writing on the methodology of theory building that appeared in course handouts, journal articles, and monographs. The requests of students and of colleagues has indicated to me that it is time to bring together and complete my writing on the methodology of theory building, particularly as it relates to theory of human social life. Especially important are the requests of students and colleagues from non-English speaking countries for a text to make available to others through translation. Here then is my attempt to meet your requests.

Captiva Island, 1986

Schema 1: Methods Involved in Theory Building

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While it now is patent that criticism must precede construction, it is not yet obvious that there are steps prior to criticism. One must be able to recognize theory if one is to critique it. Unfortunately, from a technical standpoint, not always is the term 'theory' used correctly. Not everything called 'theory' is theory. Not any speculation about something is theory. Also not everything that is theory is called 'theory'. Sometimes, in fact quite often, theory is called 'model'. So I shall begin with an explication of the nature of theory and how one can determine what is or what is not a theory.

Moreover, there is not only one kind of theory. For example, not all theory is scientific, although some have and do hold such a limited view. Philosophical theory is at least one other kind, but there are yet others. Differences in kind modify the methods involved in theory building. Consequently, the step after recognizing theory is determining the kind of theory it is. So after setting forth the nature of theory and the procedure for recognizing it, I shall discuss the kind of theory and how one can determine the kind.

To summarize, the text to follow will consist of the following sections:

1. Recognizing Theory
2. Determining the Kind of Theory
3. Explicating Theory
4. Evaluating Theory
1. RECOGNIZING THEORY

'Theory' is derived from the Greek 'thoria' which means contemplation, reflection or a popular notion than one's own speculation or conjecture about something. For example, if one is in a bad state and his student is falling due to a bad state of mind, however, such a popular notion does not up the technical sense of 'theory' in 'Einstein's' theorie of relativity. 'Greew's' theory of education', 'Weber's theory of organization' and other like expressions. In this section of the text, I shall explicate the technical sense of 'theory'.

To begin the explication let us return to ancient Greece and to the thought of one of its foremost philosophers, Aristotle (384-322 B.C.), Aristotle separated theoria (speculating or contemplating) and pragmata (acting). Theoria consists of rational activities related to knowledge or universals, while praxis consists of rational activities related to moral activity (morali alia). Frorely speaking, theoria is not limited to a making for its own sake (fine or intrinsic arts) but also includes useful making such as building a house or till the soil is clearly a functional or instrumental making, while making an abstract design is clearly not color on a canvas is a fine or intrinsic making. The former is for the sake of something else; the latter is for the sake of itself.

Since 'theory' (when theory meets certain standards) is the term for the knowledge achieved through theoretical practice' is the speculation and not upon practical. Nevertheless, theory does have a theory is that provides principles for practice. These principles can be used in practice, provided a developmental bridge is provided through praxis, the rational activities directed toward what to do.

Given that theory when it meets certain standards is knowledge, the nature of knowledge must be considered. First, knowing should be distinguished from knowledge. Knowing is a psychological state in which one has certainty about something and has a right to that belief. That is to say, it is a state of true belief. Knowledge, however, is required knowing. Because theory that meets certain standards is knowledge and so the nature of the body of truth, it is not correct to say 'that's merely theory and not a fact.' Theory can be fact; it can be true.

Theoreti-cal fact is a certain kind of fact; it is fact about universal. All universals are forms or essences. For example, theoretical fact that all human beings are mortal is common to all occurrences of learning no matter where or when they occur. Theoretical fact sets forth the essential characteristics or properties of a class or type. Learning behavior is an essential characteristic of learning is not a theoretical fact; learning a change in psychical state is an essential characteristic of learning is not a theoretical fact; theoretical knowing is grasping all of the essential properties of learning.

Universals must be distinguished from individuals that are characterized through universals. However, the distinction cannot be made in terms of class and elements. Not all classes are universal. To be a universal, a class must not be limited in time or place. For example, learning is a universal class because learning is not limited to organisms of the planet earth at this time. The class of learning is universal for it includes all human beings and organisms wherever and whenever they are in the universe.

If the limitation is in terms of logical generality and not in terms of time and place, as in the case of human learning the class is still universal. It is not an objection that human beings learn for their survival until approximately a million years ago. If they had appeared earlier in the universe any time is included, then it is not correct to say 'it is a fiction in theory but it won't work in practice' given there is no developmental bridge. The developmental bridge is provided through praxis, the rational activities directed toward what to do.

In summary, complete theoretical fact is fact about essential properties and their relations. Such a theoretical fact, of course, is possible only for omniscience.

Theoretical knowledge being knowledge of universals is expressed in certain kinds of statements. The statements are generalizations in the particular or singular statements. Generalizations are all-statements and some refer to every one of the elements of a class, particular statements are some-statements and some refer to not all elements but to at least one non-specified element of a class. Singular statements are this-statements and refer to a given or specified element of a class. An example of a statement expressing a generalization is intermittent practice is more effective in producing learning than is continuous practice.

In this statement reference is to every one of the intermittent practice events and every one of the continuous practice events. The generalization can be reworded to make clear that it is an all-statement: all instances of intermittent practice are more effective in producing learning than all instances of continuous practice.

But to express knowledge of universals, theoretical knowledge, statements must be generalizations of a certain kind. The generalizations must be for any place or time. If one can attach the phrase in all regions of space and time it is true that to all instances of intermittent practice are more effective in producing learning than all instances of continuous practice, then it is a statement of knowledge of universals and so theoretical knowledge.

Statements of knowledge of universals are called 'natural laws'. They are called 'natural' insofar as they are about things within time and space, and they are called 'laws' insofar as they apply to these things without exception. Theoretical knowledge, thus, is constituted by natural laws or true universal statements.

In the light of the discussion of the expression of knowledge of universals through natural laws, it does not make logical sense to treat natural law as different than theory. The source of this difference of a different approach is the level of generality of the universal statements. To illustrate the point, the generalization P + Q = X is called 'Boyle's Law', while the higher level generalization P + Q = X + Z, which it is inferred are called 'the Kinetic Theory'. All true universal statements, no matter their level of generality, are laws.

Yet it does not make logical sense refer to a natural law taken by itself as theory. Theory that is knowledge is a system of law-like statements. Consequently, universal statements are interrelated to form what we may call 'Boyle's Law' in and of itself is not theory; it is a part of the Kinetic Theory insofar as it can be inferred from the Kinetic Theory. Boyle's Law is part of a deductive system of universal statements.

The rationale for the assertion that the universal statements constituting a theory must be related in a systematic way is that the heap of law-like statements cannot pretend to knowledge. Universal knowledge, however, to have theoretical knowledge is to have theoretical fact about essences and properties of their relations. Such theoretical fact can be represented by a systematic statement. This requirement will be reflected in one of the criteria for the truth of a universal statement: its coherence or fitness within a system.

Given the above discussion, it is clear why Rudner, a contemporary philosopher of science, defines 'theory' as 'a systematically related set of statements, including some law-like generalizations' (1966, p. 10). Any expression to be a theory that is knowledge must be constituted by universal statements that are systematically related.

Rudner's addition to this definition, 'that is empirically testable', however, is not acceptable for a general
definition of 'theory'. Being empirically testable rules out theories whose truth does not depend upon observation, such as mathematical and philosophical theories. Rudner, of course, was defining 'theory' in the context of social theory, and so one cannot conclude that Rudner numbers among those who would limit theory to scientific theory. To make Rudner's definition include all theory, it should be modified by deleting 'empirically'. The addition should read "that is testable".

This explication of theory in a technical sense is based upon logical analysis and can best be summarized in terms of the moves involved in such an analysis.

The logic of anything is its order. Order is constituted by structure determined by content. Thus, the content of a building is its materials and the way they are arranged. The structure is determined by the building's function. Consider that reinforced concrete is utilized in buildings that are to withstand compression. With respect to order in language, the term 'semantics' has been used for content, 'syntactics' for form, and 'pragmatics' for function. (See C. W. Morris, FOUNDATIONS OF A THEORY OF SIGNS.)

In theoretical language, just as in any language, there is order. What I have done in the above explication of theory is to present an analysis of that order. Theoretical language since it pretends to present theoretical knowledge must function to present what could be theoretical knowledge, that is knowledge of universals. To function to present knowledge of universals, the content of theory must be the characterization of essential properties and their relations, and the syntax must be universal statements that are systematically related.

It should be noted that the term 'theory' can be used in a descriptive or a normative sense. The descriptive sense of 'theory' involves no evaluation of theory according to criteria or criteria like general normative judgment of theory is involved in the descriptive usage of 'theory'. The normative sense of 'theory' does involve evaluation of theory according to a criterion or criteria; normative judgment of theory is involved in the normative usage of 'theory'. To avoid ambiguity, 'function' should be used for the descriptive sense, and 'theory' with a modifier indicating the kind of evaluation should be used for the normative sense. For instance, 'true' should be added to 'theory' for the normative sense of 'theory' in which it refers to theory evaluated to meet knowledge criteria. In the above explication, I have been using 'theory' in its descriptive sense.

Since theories are called 'models' under certain conditions, it is important to understand what a model is and why such usage occurs and why it might not occur.

To begin, something that bears a similarity to something else is said to be a model. For example, a small plane built by a small boy from a kit for a model of an actual four person mono-wing plane. Notice this is a model-of. Undoubtedly there were more than one model-for the kit that preceded its actual manufacture in order to prove its design. Models of course, were physical ones. But also there can be conceptual models-of. An example of a conceptual model-of is a set of equations for simulation drawn from a theory of student retention, while an example of a conceptual model-for is the theory of natural selection used to devised a theory for student retention.

The cited example of a conceptual model-for indicates that theory can be devised from models. Modelling, therefore, can be a part of theory construction. However, a model-for theory is not theory; it is a theoretical model. On the other hand, the cited example of a conceptual model-of indicates that models can be devised from theory. Models are devised from theory so that theories can impact upon practical decision-making. This modelling from theory is part of PRACTICE referred to earlier. It is through rational activity such as these, that we know what to do. Again a model-of is not a theory; it is a practical model.

Given the difference between theoretical model and theory and between practical model and theory, what conditions then lead to the equating of theory with model? First, whenever theories are stated in terms of mathematics, they are called by some 'models'. This calling is based upon taking the theory to be a model-of the mathematics, because it is interpreted as a model, a model of a mathematical theory. Second, theories are radical departures from previous theory or not fully established theories are called by some 'models'. This calling is based upon the lack of distance of the model from the theory-model, i.e., from the theoretical model which is the well-developed understood system from which it was devised, and so the seeing of it as the theory-model from which it was devised. Finally, whenever theories are stated, they are called by some 'models'. This calling is based upon taking the theory to be a model-of reality, because of simplification it is only like reality, it is a substantive interpretation of reality.

Theories should not be taken as models-of their theory models or of the reality to be theorized about nor should they be taken as the theory-models from which they are derived. To avoid doing so, confusion the construction and use of theories. Theories are not themselves models, but can be constructed through models (models-for them) and can be used through models (models-of them).

Now that theory and model have been explicated, we are in a position to recognize that to recognize a theory means that we can set forth the essential characteristics of theory so that they can be used as criteria for membership in the class designated by the term 'theory'. Criteria for membership are standards for judging whether an individual belongs to the class.

The essential characteristics of theory were set forth by means of a logical analysis of theory. Logical analysis is in terms of pragmatics, syntactics, and semantics. Thus, pragmatic, semantic, and syntactic criteria emerged. The pragmatic criterion is functioning to attempt to produce knowledge of universals. The semantic criterion is content that attempts to characterize essential properties and their relations. The syntactic criterion is form that attempts to be universal statements which are systematically related.

To summarize: If you can answer the following questions in the affirmative, then the statements under consideration can be called 'theory':

THE SEMANTIC QUESTION:
Does the content of the statements attempt to characterize essential properties or their relations?

THE SYNTACTIC QUESTIONS:
Are the statements attempts to express generalizations that are for any time and any place?
Is there an attempt to systematically relate the statements?

Given that you can answer the above questions in the affirmative, the following question also can be answered in the affirmative:

THE PRAGMATIC QUESTION:
Do the statements function to attempt to present knowledge of universals?
2. DETERMINING THE KIND OF THEORY

After recognizing theory, one must be able to determine what kind of theory it is. The determination is necessary, since different kinds of theory have different specifications within the general structure and function of theory.

Plato, long ago, recognized the many in the one:

STRANGER. And here, if you agree, is a point for us to consider.

THEAETETUS. Namely?

STRANGER. The nature of the Different... appears to be paccelled out, in the same way as knowledge.

THEAETETUS. How so?

STRANGER. Knowledge also is surely one, but each man of it that commands a certain field is marked off and given a special name proper to itself. It recognizes many arts and many forms of knowledge. (Sophist, 257c)

One must understand the many forms (kinds) of theory if one is not to apply the wrong art, i.e., if one is not to criticize or construct theory erroneously.

Knowledge, and so theory, is many insofar as it can be divided into disciplines. To define a discipline is, for Kant, to determine accurately that peculiar feature which no other science has in common with it, and which constitutes its specific characteristic. The characteristic of a science is a simple difference of object, or the source of knowledge, or of the kind of knowledge, or perhaps of all three. This characteristic, therefore, determines the idea of a possible science and its territory. (Prolegomena to Any Future Metaphysics, Paragraph 1)

Kant, of course, is using 'science' in its more traditional sense where it encompasses all of knowledge. In the same way, 'philosophy' is such an encompassing sense. I shall eliminate this confusion by following contemporary practice and restricting the sense of both 'science' and 'philosophy' not the second 'philosophy' on my diploma which reads:

Doctor of Philosophy

The diploma does not contain a redundancy.

Moreover, Kant is using 'kind' in a more restrictive sense that I am. For Kant, 'kind' refers only to a sort based on whether the knowledge is synthetic or analytic. For me, kind is any sort.

On the basis of a difference in object one may sort theory into three classes: physical, biological, and hominological. Objects appearing to us can be given meaning either as physical or living or human phenomena. 'Either...or' is being used in a non-exclusive sense. A phenomenon, thus, could be given meaning in terms of more than one alternate. This non-exclusivity is necessary, since it is possible that a being given meaning as physical phenomena also can be given meaning as living phenomena and phenomena that can be given meaning as human phenomena also can be given meaning as physical phenomena. However, in the case that the phenomenon that can be given meaning as living would be given incomplete meaning through the physical alone; in the case that the phenomenon that can be given meaning as human would be given incomplete meaning through only the biological and the physical, and through the physical alone.

An example of such incomplete meaning is Skinner's theory of human learning. Skinner gives meaning to the human phenomenon of learning through only the physical and the biological. His methodological behaviorism. Why does Skinner do this? The answer lies in metaphysical materialism which governs Skinner's thinking.

Metaphysical materialism differs from what is usually taken to be materialism. 'Materialism' commonly is taken to refer to a position in which the good life is characterized in terms of economic gain. This is an ethical position, since ethics treats of standards for right human conduct. 'Metaphysical materialism', however, refers to a position about the nature of reality, since metaphysics is the subject of metaphysics. 'Metaphysics' derives from the Greek meta to physis and received its name from the editors in the first century B.C. who classified Aristotle's works. His work on what he called 'first philosophy' or the nature of being came after his three together, called 'physics', and so to meta physis biblia (the books after the books on nature). The position about the nature of reality taken in metaphysical materialism is the material and materialist.

Thus, for Skinner, mind or the psyche is ruled out. All of human phenomena can be given meaning in terms of states which hominological beyond the physical and the biological, for Skinner, is meaningless.

I realize that the term 'hominological' is not usual in the literature. There were reasons why I introduced it in 1963. None of the extant terms indicated the true concern which was the human being. 'Behavioral' refers to any animal behavior, not only that of the human. 'Social' likewise includes too much; ant behavior too is social. Also, in another sense, 'social' includes too little; the psychological which emphasizes the individual is ruled out. 'Psychological' too has a difficulty, even though it does not include too much: it includes too little, it rules out the social. 'Anthropological' is usable from the standpoint of its derivation from the Greek 'anthropos' meaning man. 'Anthropological', however, particularly in the United States, has come to refer only to a part of human phenomena, the origin and development of human being both in the physical sense (Phylogenetic Anthropology) and in the cultural sense (Social Anthropology). 'Hominological' does work well, since it indicates the family Hominidae which has as its only extant species Homo sapiens, the contemporary human being.

Theory of education would be categorized as hominological, since education is a human phenomenon. To make clear that education in a human phenomena, the meaning of education must be set forth. The phenomenon of education has been given many meanings, but a choice of meaning must be made in terms of whether or not the meaning sets forth the essence of education.

Obviously, education has to do with learning. However, learning can either involve consciousness on the part of the learner and so intentionality or not involve consciousness on the part of the learner and so non-intentionality, and also learning can involve guidance or non-guidance of the learner. Thus, learning can be either non-intended and non-guided, intended and non-guided, intended and guided.

Learning that is neither intended nor guided is fortuitous learning; it is chance learning. Notice that fortuitous learning is not the same as vicarious learning or incidental learning. Also, direct learning, non-intended and non-guided, can be viewed as such direct learning insofar as learning takes place through an intentional phenomenon, to the extent that some understanding is taken to be a phenomenon. Learning involves the understanding.

Both vicarious learning and intentional learning need not be fortuitous; either could be intended or guided.

Learning that is not-intended but guided is training. I am aware that 'training' is used for learning taken to be a human phenomenon. Some talk of training teachers, but do so in the sense of 'drill', that is, trained are trained but not teachers. Non-conscious animals may be trained (training comes from the Latin 'trahere' to drag along) but 'trahere' does not mean that Homo sapiens, no matter how young, is ever non-conscious. Perhaps one should question the concept, toilet training.

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but also feeling. Consequently, human learning is forming
positions in the sense of cognitive structures as well as
conation and affective ones.

Since ‘education’ is derived from the Latin ‘educare’ to
lead out, I use the term ‘discovery’ to characterize learning that is intended but not
planned. Doing so is perhaps the best way to be a kind of
learning: a disciplined discovery learning. This,
course, does not make education as broad as human learning
but restricts it to guided human learning. Educa-
tion, then, becomes the teaching-learning process. Teach-
ing is a process of guiding learning, and studentizing is a
learning process of a conscious learner, or one or oth-
er learning.

The following schema, Schema 2, presents at a glance
the four kinds of learning.

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where 'L' stands for learning
'I' stands for intended
'D' stands for guided
'E' stands for not

Schema 2: Kinds of Learning

'Learning' besides being used in a process sense, as
above, is used in an epistemological sense as a teaching
activity, or as a process of learning. Consequently, the
word ‘learning’ is a process of learning. The whole
process adds effectives to ‘learning’ and ‘education’ in the
process sense. The process of learning or the process of education is what the learner realizes. Therefore,
learning in the achievement sense should be called ‘effective
learning’, and education in the achievement sense should be
called ‘effective education’. The terms ‘learning’ and ‘edu-
cation’ should be used without modification when these
terms are used to refer to learning and education in the
process sense.

Realization of the process is not always good in the
intrinsic sense. It is, of course, good in the instrumental
sense, because the means are good in realizing the end. It
is just that the end may not be worthwhile. We may be
effective in the American society in educating young people
to be competitive, but to be competitive is not to be good as
human beings. Such effective education is not worthwhile,
good or bad in and of itself; it is not intrinsically good. Only
education that is effective in producing good human beings
is worthwhile, not only intrinsically good.

Schema 3 indicates what ought to be the relationship
between education, effective education, and worthwhile
education. Education, however, is not always effective, and
effective education is not always worthwhile.

\textbf{WE} stands for worthwhile education
\textbf{EE} stands for effective education
\textbf{E} stands for education

Schema 3: Education, Effective Education, and Worthwhile Education

It too should be pointed out that education is not as
narrow as expected. The teaching-learning process that
speaks of someone as ‘as learnt’. The same kind of
process is also used for ‘as learnt’. To eliminate ambiguity, it should be
noted that ‘learning’ and ‘educating’ in the process sense adds effectives to ‘learning’ and ‘education’ in the
process sense. The process of learning or the process of education is what the learner realizes. Therefore,
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Not all cognition is theoretical in nature. There are
qualitative and quantitative cognitive structures as well.
Qualitative structures differ from theoretical structures
insofar as the latter are quantitative. Theoretical struc-
tures allow one to shape and group instances; they are
universal and true generics that are independent of time and
place. Although ‘quantitative’ in a common sense pertains
to numbers, in its technical sense it involves extension. Generals independent of time and place are universal classes
and so have range. ‘All’ is a quantifier. On the other
hand, qualitative structures, if adequate, allow one to be
sensuous; unless one takes ‘man’ only in the sense of adult
man, but why do so? But there is another difficulty.
‘Androgyny’ is limited to males and so is a masculine term.
‘Androgynous’ means man in distinction to ‘woman’
meaning woman (consider the term ‘androgynous’). If one desires a term for the study of adult education, ‘adult educology’ is per-
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of the general study of education which is educology.

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of the general study of education which is educology.

On the basis of the object of knowledge, theory of edu-
cation is homologous. Also by the very nature of theory,
theory of education is quantitative educology.

Turning now to the source of theory, two kinds of
theory can be sorted out: theory that is a priori and
theory that is a posteriori. Theory that is a priori consists of statements whose possible truth is necessary, i.e.,
whose truth is ascertainable by reason alone. Theory that is
a posteriori consists of statements whose possible truth
is contingent, i.e., whose truth is ascertainable by experi-
ence.

One also notes that on the basis of what he called
‘kind’ into analytic theory and synthetic theory.

- there is in them a distinction according
to content, for they are either merely
explicative and add nothing to the
theory itself, or they are a posteriori
analytic judgments, the latter synthetic judgments.

PROLEGOMENA TO ANY FUTURE METAPHYSICS, Paragraph 2)

Analytic theory, then, is formal theory. Mathematics
and logic in their syntactical dimensions consist of formal
theory. Mathematics and logic, in fact, is formal theory
when they are pure, do not add to the content of knowledge.
They are the disciplines of formal knowledge. For example,
geometry is formal theory when it is well enough.

This theory, the other hand, is not theory of
form but of content. Its main business is to add to the
content of knowledge. Science, praxisology, and philosophy
consist of theory of content.

When we cross over the two classifications of theory,
three classes of theory emerge: a priori, analytic, a
priori, synthetic, and a posteriori synthetic. See Schema 5 below.

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priori, synthetic, and a posteriori synthetic. See Schema 5 below.

It will be noted that a posteriori analytic theory is not
included as a logical possibility. The category is con-
tradictory, and so must be ruled out. Since analytic theory
is of form and not of content, it cannot treat of experi-
ence. Since what does not treat of experience cannot have
its truth ascertained in experience, the analytic cannot be
presents the nature of the reality which is education through a description, it is called ‘descriptive metaphysics of education’.

Education was seen to be a teaching-learning process. As such a learning process, it has four basic properties. First, education must be characterized as having a teacher, a learner, who is self-aware, i.e., conscious and so intending. These two properties of education are obvious from education as a teaching-learning process. Secondly, education is characterized as having a curriculum. Finally, education is characterized as having a learning process, a third basic property emerges. There must be a content to be learned, i.e., signs for psychological structuring. Finally, the intended context in which it occurs. Learning is no exception. However, the context should not be taken in a narrow sense. The context is not only physical, it is more importantly social. In descriptive metaphysics of education, then, one sets forth the essential properties of teacher, student, content, and context. One, through this part of philosophy of education, knows what it is to be a teacher, what it is to be a student, what content is essential, and what context for human guided learning is. A set of descriptors is provided, that one can get on with the task of characterizing the relations between teacher, student, content, and context. These descriptors are requisite to the remainder of philosophy of education, to science of education, and to praxiology of education. Since this follows presents the outline or a map of descriptive metaphysics of education.

\[
E = T \cup S \cup C \cup X
\]

\[
T = T_1 \cup T_2 \ldots \cup T_n
\]

\[
S = S_1 \cup S_2 \ldots \cup S_m
\]

\[
C = C_1 \cup C_2 \ldots \cup C_p
\]

\[
X = X_1 \cup X_2 \ldots \cup X_q
\]

where ‘E’ stands for the set of the essential properties of education

‘T’ stands for the subset of E which consists of the essential properties of teacher

‘S’ stands for the subset of E which consists of the essential properties of student

‘C’ stands for the subset of E which consists of the essential properties of content

‘X’ stands for the subset of E which consists of the essential properties of context

Some logicians of science, for instance Rudner (1966), take descriptive theorizing not to be theorizing. Given that descriptive theorizing is not to be theorizing, this is seen as pre-theoretical in nature. Rudner's position, however, rests upon a positivistic orientation which rejects philosophy as descriptive, as well as ontological. Philosophy, on the other hand, is seen as characterizing relations, whether the relations are essential or contingent, is still description. Undoubtedly, theory that describes relations is called ‘theory’, because such descriptions can be used to explain in the sense of characterizing causal relations.

Sometime descriptive metaphysics is seen as the result of a co-called ‘naturalism’ and this is ambiguous and, in part, erroneous perception. First, descriptive inquiry is seen as naturalistic, because it is seen as an attempt to describe the natural world. However, it is thought that the first or natural history stage of inquiry is the description of phenomena through setting forth their properties, that is, descriptive, i.e., categorization. In the second stage of inquiry is taken as explanation, i.e., setting forth why a phenomena has a property through relating phenomena to other phenomena. Explanation has not the use of ‘natural’ renders the theoretician passive when the theoretician is active in constructing signs to understand phenomena. A theoretician, by defining the term 'natural', cannot lead to a multiplicity of perspectives, cannot be honored, nor ought they be neglected. Aphenomena has its essence which can be grasped provided one can see it intellectually. This asser-
tion does not settle the nominalist-realism controversy, for that is a controversy as to whether an universal, an essence, has an independent existence or is a name for what exists in the phenomena. Nor need this controversy be settled to describe phenomena. What is at stake is what is beyond the phenomena. Theory about phenomena does not address what is beyond phenomena.

Secondly, descriptive inquiry is seen as naturalistic, because it is thought that quantification is not involved in settling forth description. This has led also to calling descriptive inquiry 'qualitative'. However, I have argued above that whenever categories are used, and they are in description, then quantification obtains. Qualitative inquiry does not occur.

Thirdly, descriptive inquiry is seen as naturalistic, because the phenomena are taken as given to the senses and not to the intellect. So taking the givenness of phenomena eliminates the subject. Such an elimination renders impossible the grounding of theory in intellectual penetration into phenomena. Subjectivism must be acknowledged. But in such acknowledgment does not lie rejection of truth for negotiated consensus.

Descriptive theorizing is one part of philosophy of education, but philosophy of education is more than descriptive metaphysics of education: it also has as its branches: ethics of education, social philosophy of education, epistemology of education, and aesthetics of education. These branches of philosophy of education characterize the essential relations within guided intended learning. Ethics and social philosophy of education characterize those with respect to goodness, epistemology of education with respect to truth, and aesthetics of education with respect to beauty.

Because philosophy treats of the essential and not the accidental, its truths are necessary not contingent. Thus, in philosophy, truth is based upon reason. Now it is not necessary to establish essential properties. Essential properties must be intuited or directly observed by the intellect. Intuitive reasoning is non-discursive. The phenomenological method presents the formal patterns for intuition, and to these methods I shall turn in the section on the construction of descriptive metaphysics or theory.

Notice that observation in intuition is not sensory. That is why descriptive metaphysics which depends on experience is still a priori. The experience that is referred to in the a posteriori method is sensory. Since the other thing that philosophy does—the establishment of essential relations—is a matter of deductive reasoning, this other part of philosophy too is a priori. Hence, all of philosophy is a priori.

Both science and praxiology are a posteriori. Contingent necessary relations are set forth, and so establishment depends upon inductive reasoning not deductive or intuitive reasoning. Descriptive reasoning involves data, and so sensory experience. Induction is a statistical argument, since the inference is from a number of instances to the whole collection of instances.

However, science and praxiology differ as to the content they add to knowledge. Science does not add any axiological content to knowledge as philosophy and praxiology do. Yet the axiological content of praxiology differs from that of philosophy. Praxiology treats of instrumental value, while philosophy treats of intrinsic value. In other words, praxiology treats of effectiveness, while philosophy treats of worthwhileness. To treat of effectiveness is to treat of what means are effective with respect to a given end or ends. Effectiveness, of course, can be established by sensory observation, but worthwhileness cannot.

Since a practice is an organized doing, i.e., means interrelated with respect to the production of an end or ends, knowledge of effectiveness would be knowledge of ideals of practice. What we want to know is what means best effect an end or ends.

The term 'praxiology' is not usual in the literature, at least in the United States. The concept as I utilize it should be credited to Kotarbinski. I introduced it to avoid the unwanted notions of hardware and of technique with its connotation of specificity which adheres to 'technology'. 'Methodology' could be another term for 'praxiology', but methodology remains is confused with development. Praxiology, however, is distinct from development, because it is theoretical; development is not. Development is in the domain of applied theory. Models of theory are development requirements.

Science does not treat of effectiveness, but only of effect. Science also does not treat of worthwhileness. To hold that science treats of value, other than to describe the contingent connections between valuing and factors related thereto, is to commit the naturalistic fallacy. Maxims of science are necessarily valuable either in an instrumental sense or in an intrinsic sense.

Schema 7 summarizes the possible kinds of theory according to, not the object of theory, but according to the content and form of theory.

Analytic (Formal) Logical (Syntactical)
Mathematical
Descriptive
Philosophical
Explanatory
Synthetic
Scientific

Schema 7: Kinds of Theory According to Content and Form

Schema 8 provides a crossover of the classifications of theory according to object, and according to content and form. Since analytic theory cannot have an object, no crossover is possible with respect to formal theories.

<table>
<thead>
<tr>
<th>L</th>
<th>M</th>
<th>P</th>
<th>Pr</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

where 'L' stands for logical, 'M' for mathematical, 'P' for philosophical, 'D' for descriptive, 'E' for explanatory, 'Pr' for praxiological, 'S' for scientific, 'Ph' for physical, 'B' for biological, and 'H' for homological.

Schema 8: Kinds of Theory

Now that the kinds of theory have been explicated, we are in a position to determine the kind of theory. To determine the kind of theory means that we can characterize the essential characteristics of each kind of theory so that they can be used as criteria for membership in one of the above four classes. Criteria for membership are standards for judging whether an individual belongs to a given class.

The following set of questions should provide a summary and a decision procedure for determining the kind of theory.

Yes  No

1. Is the theory analytic? It is either L or M. Go to 2.

2. Is the theory synthetic? Go to 3. Exit.


8. Is the theory non-axiological? It is PhD. Go to 10.

9. Is the theory descriptive of physical phenomena? It is BD. Go to 11.

10. Is the theory descriptive of living phenomena? It is HD. Exit.

11. Is the theory descriptive of human
phenomena?
12. Is the theory explanatory of physical phenomena?
   It is Phe. Go to 13.
13. Is the theory explanatory of living phenomena?
   It is Be. Go to 14.
14. Is the theory explanatory of human phenomena?
   It is He. Exit.
15. Is the theory about physical phenomena?
   It is Phe. Go to 16.
16. Is the theory about living phenomena?
   It is Be. Go to 17.
17. Is the theory about human phenomena?
   It is He. Exit.
18. Is the theory about physical phenomena?
   It is Phe. Go to 19.
19. Is the theory about living phenomena?
   It is Be. Go to 20.
20. Is the theory about human phenomena?
   It is He. Exit.

3. EXPLICATING THEORY

Criticism of theory consists of explanation and evaluation of theory. Since one cannot judge the adequacy of theory until one sets forth what the theory is, explicating theory will be considered first.

"Exicipation comes from the Latin 'explecaro' meaning to unfold. Thus, to explicate a theory is to unfold it, to set forth its content and form. This is necessary for most theory usually is set forth in a manner which does not make clear either its content or form.

The content of a theory is constituted by its elements or parts. The basic elements of a theory are its concepts. The concepts of theory are general ideas which describe properties of the object of the theorizing. For example, in my descriptive theory of education, teacher, student, content, and context are general ideas which describe the properties of education, the teaching-studenting process. In G. Maccia's descriptive theory of worthwhile cognitive achievement, quantitative knowing, qualitative knowing, and performative knowing are general ideas describing worthwhile student achievement, knowing.

The basic elements of a theory, its concepts, are put together into yet other elements. Concepts are related to form universal generalizations which describe relations between properties. An example would be the relating of the concept, teacher comments, to the concept, student achievement, in the universal generalization, teacher comments contribute to student achievement.

Finally, universal generalizations are related to form systems. An example would be Dewey's theory of education.

Thus, the content of a theory or its parts are: concepts, universal generalizations. Relations between concepts (concepts formed into universal generalizations), and relations between universal generalizations (universal generalizations formed into systems), give theory its form.

Theory that is to be a candidate for knowledge must be

made public. Knowledge is recorded knowing. Language is the vehicle for making knowing public.

The expressions of language are words, phrases, sentences, and related sentences. Obviously phrases are related words, and sentences are related phrases. Language, therefore, is an ordered collection of expressions. See Schema 9 below.

<table>
<thead>
<tr>
<th>LETTERS</th>
<th>WORDS</th>
<th>PHRASES</th>
<th>SENTENCES</th>
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Schema 9: Language as an Ordered Collection of Expressions

Not all language functions in the same way. Some functions to express what one is capable of expressing, and some to elicit what oneself or another is capable of expressing. Plato sorted out the cognitive, conative, and affective capacities of the human being. Thus, one can express one's thoughts which are either propositions or mandates in descriptive or prescriptive sentences respectively, one's intentions in resolutive sentences, and one's feelings in emotive sentences. The eliciting function relates also to the trinity of capacities and manifests itself in problematic and evocative sentences. Schema 10 presents a summary of the functions and kinds of sentences.

To be more specific in regard to the expressive function of language, examples will be presented and explicated. The sentence

Teacher-student interaction produces teacher-student liking

describes the relation between teacher-student interaction and teacher-student liking. This descriptive sentence expresses the proposition that teacher-student liking is a consequence of teacher-student interaction. This proposition, as well as any proposition or characterization of states of affairs, could or could not be true.

Mandates, on the other hand, are orders for states of affairs and as such cannot be either true or false.

Teachers, interact with your students
prescribes what a teacher is to do. This prescriptive sentence expresses the mandate that the teacher interact with her or his students. This order for a state of affairs, as well as any other, is neither true nor false. To be sure, one could ask why so order.

Intentions are very much like mandates in their orientation toward action and their lack of truth value. Nevertheless, intentions differ from mandates in being aims for self-action rather than orders for the action of others. The resolutive sentence

I, Teacher X, will interact with students

expresses the intention of a certain teacher, Teacher X, to interact with students. Although one can inquire into the why of this or any other intention, one cannot raise questions of truth or falsity. Aims for self-action are neither true nor false.

An unalloyed example of the remaining expressive function of language is

Teacher interaction with students, bah!

This is an emotive sentence which expresses a negative feeling toward teacher interaction with students. This feeling, as well as any other, is neither true nor false. It is what it is. Of course, its justification is another matter.

It is important to sort out normative sentences from descriptive, prescriptive, resolutive, and emotive ones. A normative sentence such as

Opportunities ought to be provided for teachers to interact with students.

expresses that there is a set of true propositions and partially endorsed mandates or intentions which imply the mandate or intention to provide opportunities for teachers to interact with students. This illustrates that normative sentences address themselves to the way of mandates or intentions. Instead of ‘ought to’, ‘must’, ‘should’, ‘is required to’, ‘has the duty to’, ‘is obligated to’, or ‘is permitted to’ is used. When one is expressing the norm in terms of rightness or wrongness, the terms ‘right’, ‘correct’, ‘permissible’, ‘lawful’, ‘proper’, ‘hidden’, or ‘wrong’, ‘incorrect’, ‘impermissible’, ‘unlawful’, ‘improper’, ‘forbidden’ appear.

Turning to the eliciting function of language, examples of problematic sentences which elicit thought and intention can be obtained by transforming illustrative sentences from above.

What is the relation between teacher-student interaction and teacher-student liking?

Are teachers to interact with students?

Will I, Teacher X, interact with students?

It is patent that the first of the problematic sentences elicits a proposition, the second a mandate, and the third an intention.

The following emotive conjugation of Bertrand Russell adapted to an educational context is a good example of the force of words to elicit feeling:

I have reconsidered, other students have changed their minds, but the teacher has gone back on her or his word.

The virtue words the student uses to describe her or his behavior calls forth a positive feeling toward her or him, while the bad words the student uses to describe the teacher’s behavior calls forth a negative feeling toward the teacher. The words characterizing the other students’ behaviors are not emotively toned as are virtue or bad words and so are neutral words which do not function in an evocative manner.

Theoretical language, of course, functions to express and not to elicit. Thus, problematic and evocative sentences are non-theoretical ones. Also emotively toned language, because it functions to elicit is non-theoretical. Moreover, not all language that expresses is theoretical; it must be language that describes and not language that sets forth mandates, intentions, or feelings. Theoretical sentences are descriptive, not prescriptive, resolutive, or emotive. Normative sentences, too, are non-theoretical because they address themselves to the justification of mandates or intentions.

If language is to function to describe it needs to be formed accordingly. It is obvious that the question form is suited to the problematic function. Schema II sets forth
the sentence forms for the various kinds of sentences: declarative for descriptive, imperative for prescriptive and resolutive, exclamatory for emotive and avocative, and interrogative for problematic. The declarative form, therefore, is the form of the sentences.

But not all declarative sentences are teleological; for the description must be of the universal and not of the unique; it must be quantitative and not qualitative. Qualitative description utilizes figurative or literal language, for figurative language permits the description of an ununiversal. To describe the truth in language is to present the embodied meaning which is unique. Figurative language permits the imagery required for such a presentation. In the opening stanza of Shelley's poem, "Mont Blanc":

The everlasting universe of Things
Flows like a Mind, and rolls its rapid waves,
Now dark--now glowing--now reflecting gloom--
Now lending splendour, where from secret springs
The source of human love its tribute brings
Of waters,--with a sound but half its own,
Such as a feeble brook will oft assume,
In the wild woods among the Mountains lone,
Where waterfalls around it leap for ever,
Where woods and winds contend, and a vast river
Over its rocks ceaselessly bursts and roars.

The figurative language (for example, "flowing everlasting universe") presents the very being of nature, the change that cannot die. Literal language cannot do this, because such language has no semantic thickness and cannot embody embodied meaning for meaning which is the whole, the one, the unique.

On the other hand qualitative description must use literal language; the language must be semantically thin. There must be a single meaning. Theoretical language, therefore, must not only be declarative but also literal in form.

The form of its literalness is categorical. To be categorical is to be certain insofar as something is predicated of something else. A precise relation between some things is given by making one a subject and the other a predicate relative to the subject. In the proposition, through the student interaction produces teacher-student liking, teacher-student liking is predicated of teacher-student interaction.

Since theoretical propositions are universal propositions, strictly speaking they only involve predicates. Only singular terms (proper names) count as subjects within modern logic. The proposition, teacher-student interaction produces teacher-student liking, would be interpreted as for all x and for all y, if x is a member of the class teacher-student interaction and y is a member of the class teacher-student liking then x bears the relation produces to y. The symbolization would be

\[(yx)(yy)(Fx \cdot Gy \cdot Rxy)\]

where 'yx' stands for x is a teacher-student interaction
'gy' stands for y is a teacher-student liking,
and
'Rxy' stands for x produces y.

The above universal proposition contains the universal quantifier, 'y', and predicates. What is involved is class logic. As pointed out in 2. classes involve extension and so are quantitative in nature. Hence, the use of the term 'universal quantifier'. Since classes are categories, the literalness of theoretical language can be called 'categorical' is this reinterpreted sense.

The predicates express the concepts of the theory, and so they are the basic linguistic elements of a theory made public. These basic linguistic elements are either words or groups of words, phrases; they are the theoretical terms.

Within theory, particularly scientific theory, some distinguish observable terms from theoretical terms. Observables are the ones that are operationally definable. Being operationally definable is not being definable in the sense of stating what characteristics mark off the universal class designated by the theoretical term from all other classes within the domain under consideration. Rather being operationally definable is being able to directly observe whether an instance falls within the universal class. The operational definition states the procedure for observing whether an instance falls within the universal class.

To illustrate, the operational definition of intelligence is not the ability to acquire and apply knowledge, but it is said to be a procedure for observing not only whether an instance falls within a class but also its rank relative to other instances where other factors, such as age, are presumably ruled out. One procedure is that involved in the Stanford-Binet Test which gives a value, the I.Q. Since the observation of intelligence can be given a value, sometimes intelligence is called 'a variable'. Strictly speaking, intelligence is not a variable, for the variable symbol, x, which can take on the set of values ranging from low to high (say 50 to 150). One ought not to confuse theoretical terms that can be related directly to observation and theoretical terms that can be related indirectly, or not at all to observation. Observation usually means sensory, but observation need not be. So the only theoretical terms that cannot be related to all observation are those of formal theory, i.e., those of logic and mathematics.

Sometimes, particularly by psychologists, theoretical terms that cannot be related directly to observation are called 'constructs', while 'variable' is used for those that can be assessed by some more or less theoretical test. The difficulty with this usage of 'variable' is clear from what has been stated above. To call only some theoretical terms 'constructive' too haphazardly will not do.

Moreover, this analysis shows that a better sort than observable terms and theoretical terms would be theoretical terms that can be related directly to observation and theoretical terms that can be related indirectly or not at all to observation. Observation usually means sensory, but observation need not be. So the only theoretical terms that cannot be related to all observation are those of formal theory, i.e., those of logic and mathematics.

A note of caution: just because all theoretical terms are constructs does not make all theory arbitrary. Even though the subject is the one who changes one's thoughts about the world, gives significance to the world, the experienced world cannot be an attribute of each personality. All the subjectivist's are constructed in a manner such as to multiple realities, even though there are multiple perspectives. The objects experienced are the subject's constructed in imagination. Even the objects experienced enter into a common world which transcends cognition, though it includes cognition. Moreover, not all objects should be known. Not all cognizant is knowing; not all signs of the world, giving significance to the world, are adequate. This is the internal subjective's position, and unless one takes it one is solitary amid nothing.

To set forth the terms of the theory, then, the following steps should be taken:

1. sort out the sentences that are declarative and
universal categorical,

2. list the subjects (in a logical sense, predicates) and predicates of the sentences, and

3. delete the redundancies from the list.

Theoretical terms and their definitions are set forth in descriptive metaphysics. Descriptive metaphysics, thus, is a set of interrelated and synchronous sentences which describe the properties of a system. A system is any extended object, i.e., a class object not an individuated object, from an atom to education. A description of a system may be either structural or a state description.

In a structural description of a system one characterizes the system by specifying the properties that make up the subsystems. In biology, a structural description of a system would be called 'an anatomical description.' The map of descriptive metaphysics presented in Schema 6 embodies such an anatomical approach. The subsystems of education are specified as teacher, student, content, and context. Furthermore, the specification of the primary property of each subsystem is as follows: that of the teacher, actor whose aim is guiding another's learning; that of the student, actor whose aim is his or her own guided learning; that of the content, structures for learning; and that of the context, position for learning.

Since a state of a system is its properties at any one time, a state description of a system is one in which there is specification of the change in properties from one time to another. In biology, a state description of a system would be called 'a physiological description.' The cognitive-developmental description of moral learning by Kohlberg (1966) would be a state description of a system. He specifies six stages of moral learning: 'punishment and obedience orientation', 'instrumental relativist orientation', 'interpersonal concordant law and order orientation', 'social-contract legalistic orientation', and 'universal ethical orientation'. The stages are listed in order of development from lowest to highest.

Whether a description of a system is a structural or a state description, the description is general for it is of an extended object, a class. In my case, it is of class education; and in Kohlberg's case, the class moral learning. Also to be theoretical the class must be universal, it must be time and place independent. My class and Kohlberg's are undefined.

An example of a definitional chain will now be presented. It is a presentation of some of my descriptive metaphysics of education.

1. Education of system consisting of subsystems of teacher (T), student (S), content (C), and context (X)

   T S C X

   Schema 12: Subsystems of Education

1.1. System of complex of components in mutual interaction

1.2. Subsystem of system within a system

1.3. Teacher of actor whose aim is guiding learning of another

1.4. Student of actor whose aim is his or hers guided learning

1.4.1. Learning of psychical development

1.4.1.1. Psychical development of formation of mental structures

1.5. Content of structures for psychical development

1.5.1. Structures for psychical development of structures which are either cognitive (CG) or conative (CN) or affective (AF)

   CG CN AF

   Schema 13: Psychical Structures

meant to be universal.

Notice that when you specify properties, definition is involved. A class term is used for predication of a property, since such predication is recognition that the object is a bearer of the property and so is a member of a certain class. A class term denotes all the particulars to which the term is applicable to (the extension or sense of the term). To illustrate, 'teacher' denotes all the particulars to which the term 'teacher' is applicable--Socrates, Abelard, Erasmus, Steiner, and so on, and connotes an actor whose aim is guiding another's learning.

The definition is the statement which sets forth the class term, called the definendum--what is to be defined, and the sense of the term called the definiens--that which defines. The logical convention for setting forth a definition is as follows:

   definendum =df definiens

The definiens sets forth the essential characteristics, those the particular must have to be a member of the class.

The characteristics (properties) of particulars without which the term stated in the definendum would apply are accompanying or accidental. For example, the maleness of Socrates, Abelard, and Erasmus is not essential to being a teacher; Steiner is a female.

Because essential characteristics are differences which sort out one class from another class (differentia specifica) within a universe (genus proximum), definitio is the logical product of the class (genus differentialis). Teacher is a logical product of the class of actors whose aim is guiding and the class of actors involved in the learning of others.

To order definitions into a chain, the definitions are arranged so that definitio is defined by other terms in the system. Of necessity all terms cannot be defined, since there would be no end to the process. Every system of terms has its undefined or primitive terms. The image of the chain becomes obvious if you think of each definition becoming the definitio of the next definition, and so on until the chain is completed. Of course, the last link remains

1.5.1.1. Cognitive structures of schema for thought which are either quantitative (QN) or qualitative (QL) or performative (PF)

   QN QL PF

   Schema 14: Cognitive Structures

1.5.1.1.1. Quantitative schemata for thought are either criterial (C) or theoretical (T) or instantaneous (I)

   C T I

   Schema 15: Quantitative Schemata for Thought

1.5.1.1.2. Qualitative schemata for thought are either appreciative (AP) or acquisitive (AC) or affective (AC)

   AP AC RC

   Schema 16: Qualitative Schemata for Thought
is needed in describing a taxonomy.

To be more precise, then, a taxonomy is a classification in which

1. its classes (a class is called a 'taxon' symbolized by 'T') are arranged in ranks from 1 to n;
2. every T of rank j where j ≤ n is included in a T of rank j + 1; and
3. the number of T's of rank j is greater than those of rank j + 1.

In Schema 18

1. the T's are arranged in ranks from 1 to 4;
2. every T of rank j where j ≤ 4 is included in a T of j + 1 (for example, every taxon of rank 1 is less than 4--is included in a T of rank 2--1 + 1, T, and C in QM; AO, AC, and AP in QL, and PR, CN, IN, and CR in PF); and
3. the number of T's of rank j is greater than those of rank j + 1 (for example, the number of T' of rank 1 is 15--10 plus the other 5 T's brought down undivided from ranks 3 and 4--and is greater than those of rank 2--1 + 1--which is 8--3 plus the other 5 T's brought down undivided from ranks 3 and 4).

Now my earlier statement that the classification presented in Schema 18 is a taxonomic one is justified.

Yet another way in which classifications can be made more complex is through cross-partitioning. One partitioning can be crossed with yet another partitioning. The two partitionings being crossed could even be taxonomies. Recall that in my discussion of kinds of theory, I set forth a classification that was a cross-partitioning. I partitioned the universe of theories into kinds on the basis of their content and form. A taxonomy emerged in which the lowest ranking T's were logical theory, mathematical theory, descriptive metaphysics, explanatory metaphysics, praxiological theory, and scientific theory. Also I partitioned the universe of theories into kinds on the basis of their objects. A classification emerged in which the classes were physical theory, biological theory, and homological theory. Then I crossed over these two partitions and 18 classes could have been obtained. However, it had to be ruled out, since logical theory and mathematical theory are formal theory and so have no object.

Typologies are classificatory theories since they partition a universe into types and so into classes. Some people would be Reisman's types of human being: inner-directed, outer-directed, and autonomous, and Popper's types of society: open and closed. Sometimes 'typology' is used only as a classification in which membership in the classes can be directly observed, operational definition of the classes is possible, and values assigned to the members in accordance with scales.

It is important to not confuse description or classification with descriptive theory or classificatory theory. Because of such theory's operational definition we must describe them. Without classificatory theory one would not know how to divide particulars into groups.

To conclude this section on explicating the terms of the theory, the following steps are involved in ordering the terms:

1. sort out the theoretical definitions from the operational definitions,
2. list the theoretical definitions,
3. sort out the theoretical definitions that present classifications from the theoretical ones that do not, and
4. order the definitions in a chain.

As seen above, explicating the terms of a theory results in also explicating the descriptive theoretical sentences of a theory. The descriptive theoretical sentences are the definitional sentences. Given the theory is only description of the properties of a system, it is only descriptive metaphysics, then only definitions are involved. Thus, when one explicates the terms, the task of explicating the theory is complete.

However, if the theory goes beyond description of properties into description of relations between properties, then more explicating is required. There are yet other theoretical sentences and relations between these sentences to set forth.
The other theoretical sentences relate terms of different logical levels so that some (resulants) follow from others (determinants). Given statements which are deterministic in form, explanation is possible. For example, one can explain why student achievement did not occur in the absence of motivation on the basis of a theoretical sentence relating student achievement as resulant to motivation as determinant. Thus, these other theoretical sentences are called "explanatory".

Among the explanatory theoretical sentences, there are two kinds: those that set forth necessary relations between the determinants and the resulants and those that set forth contingent relations between the determinants and the resulants. Philosophical theoretical sentences set forth necessary relations, and both scientific and praxiological theoretical sentences set forth contingent relations.

Turning first to necessary relations between the determinants and resulants, these are relations that are essential and so arise from the very nature of the determinants and resulants. These relations have to hold or the determinants and resulants would not be what they are, but would be otherwise.

For example, the resultant, liberal content of education, follows from the determinant, student achievement objective of autonomy. This following is essential and so arises from the very nature of liberal content and autonomy. To be liberal content is to be knowledge. To be autonomous is to be an I, a decision-maker. Since being a decision-maker implies knowledge, given the student achievement objective of autonomy, liberal content follows. Autonomy and liberal content would have to be otherwise not to have this relation hold.

Contingent relations between determinants and resulants, on the other hand, are accidental and so do not arise from the very nature of the determinants and resulants. These relations do not have to hold for the determinants and resulants to be what they are. For example, the resultant, skill achievement, follows from the determinant, intermittent practice. The following is accidental and so does not arise from the very nature of intermittent practice. Skill achievement is development of performative facility, while intermittent practice is repeated performance that is discontinuous. Development of performative facility does not imply repeated performance that is discontinuous. It is conceivable that certain learners would require no repeated performance to develop performative facility. Given eidetic imagery, a performance of another conceivably could suffice. Moreover, it is conceivable that certain learners might require repeated performance but which need not be discontinuous, and which even may need to be continuous. This conceptual possibility is based upon other factors relative to learners, such as standards and memory. Thus, the relation between skill achievement and intermittent practice could be otherwise without skill achievement and intermittent practice playing any role.

Both scientific and praxiological theoretical sentences express contingent relations. The difference between the two is that they may not with respect to content. As noted earlier, scientific theoretical sentences do not have any axiological content while praxiological theoretical sentences do.

Scientific theoretical sentences express accidental relations between properties so that effects of one or more properties upon one or more other properties are described.

An example would be Group cohesion produces group influence on its members.

An example would be Group cohesion decreases the willingness of the resultant, group influence, of its members. The effect of group cohesion on group influence of its members is described by the determinant of the resultant, group influence of its members.

Praxiological theoretical sentences express accidental relations between properties so that the effectiveness of one or more properties in affecting one or more other properties is described. In such cases, different sentences express universal generalizations about instrumental value, i.e., what means are effective, instrumentally good, in bringing about an end or ends.

An example would be Advance introduction of relevant subsuming concepts facilitates retention of unfamiliar but meaningful verbal materials.

Free will would be ruled out. Non-determinism permits only chance happenings. Given only chance happenings, the human being could not be a determining force. There would be no determining forces. Just anything could happen. Thus, non-determinism not determinism is antithetical to free will.

But there is a position that is antithetical to free will. It is a position that Skinner takes, the position of physical materialism. Such a position rules out self-determinism, since the psyche is denied and so the self as decision-maker.

Although all theoretical explanatory sentences are deterministic in form, some are symmetrical with respect to determinants. What is involved is that the determinant playing also the role of the resultant, and the resultant also playing the role of the determinant. An example would be the relation between interaction between persons and liking between persons. Symbolization should make clear what is involved in symmetry

\[ D \leftrightarrow R \]

where 'D' stands for interaction between persons, 'R' stands for liking between persons.

Clearly interaction between persons leads to liking between persons and vice versa.

Besides modification of explanatory theoretical sentences according to symmetry, there is modification according to the complexity of determinants and of resulants. Also to be considered is the intermittent practice in which the determinants and of resulants. In all the examples of theoretical sentences given above, the determinants and the resulants were complex and of different truth value. However, complexity or negative truth value is possible. With respect to complexity, there can be one or more determinants related either as conjuncts or disjuncts of resulants. Related either as conjuncts or disjuncts of resulants. The following schema

\[ D_1 \land D_2 \Rightarrow R \land \neg R \]

where 'A' stands for and, 'V' stands for either... or.

is complex insofar as it has two determinants that are conjuncts and two resulants that are disjuncts. To be a con-
junct is to be part of a compounded property. All of the
conjunctions are required in the determination. Both $D_1$ and $D_2$
are needed as determinants. To be a conjunct is to be an
alternate for some condition. Either $D_1$ or $D_2$ can
be the resultant or both $D_1$ and $D_2$ can be resultant.

Turning to negative truth value, the theoretical
sentence,

**Without student believing there is no student
knowing**

can be symbolized as

$$D + \neg R$$

where $D$ stands for not,

$\neg$ stands for student believing

$R$ stands for student knowing

In this theoretical sentence, no assertion is made that stu-
dent knowing follows from student believing, only that if
student believing is absent so will be student knowing.
Student believing is a necessary condition but not a suffi-
cient condition for student knowing.

There are yet two other modifications of explanatory
theoretical sentences, but these are restricted to those
expressing contingent relations. These are modifications ac-
cording to time and according to certainty.

The scheme for modification according to time is

$$D_t + R_t$$

where $t$ stands for time

It should be noted that explanatory theoretical sentences
without a time modification do not present invariant se-
nuences. The determinant is not taken as prior in time to
the resultants. It is not to be interpreted as a leading
in time. Thus, the mechanistic point of view which involves
a linear sequence is not embraced.

A mechanistic point of view is one that phenomena are
represented as a machine. A machine in an un-
that consists of parts that act in predetermined ways to
bring about certain specific effects. Thus, in such an ob-
ject the parts have natures which are non-alterable. These
parts, consequently, have fixed actions. The actions which
are specific to a certain kind of machine result from a com-
bination of parts. The effects are linear and additive.
Therefore, in a mechanistic state of affairs the emphasis is
on its parts which are taken as non-modifiable and as the
determining factors. The entire state of affairs or the
whole is not taken as a determining factor.

When the whole is taken as a determining factor, it is
so taken because of an organicist point of view. This point
of view is one that phenomena are to represented like
organisms. An organism is a structured whole, i.e., one in
which the content and form of its parts are determined by
its function. Thus, in such an object the parts do not have
non-alterable natures nor do they act interdependently to maintain
function and thereby

wholeness. The parts do not simply combine and the

wholeness is maintained and the parts change relative to a whole. Therefore, in an
organismic state of affairs the emphasis is on the whole
taken as determining its parts.

Mechanism is not to be confused with positivism. The
positivist need not have an organicist point of view; she or
he could have an organismic point of view. To be a posi-
tivist what she or he needs to do is to reject theoretical
sentences as candidates for knowledge unless they are
*posteriori*. That is to say, the positivist rejects
theoretical sentences as candidates for knowledge unless
they can be related to sensory data. They are all
other theoretical sentences as nonsense insofar as they are

testable. For her or him, only science and praxiology constitute knowledge; philosophy does not count as know-
edge. If the positivist is a contemporary one, a logical
positivist or a logical empiricist, then she or he also ac-
ceptes a *priori* analytic theoretical sentences as candidates
for formal knowledge; she or he accepts logics and mathe-
ematics as knowledge. From a different discussion of kinds of
knowledge, clearly I am not a positivist.

The scheme for modification according to certainty is

$$D + \varphi R$$

where $\varphi$ stands for probably

Often theoretical sentences in the homological sciences
take the above tendency form, because it cannot be asserted

for all cases that the resultant follows the determinant.
An example would be

**Persons of higher authority tend to receive more
prestige.**

To summarize, all explanatory theoretical sentences can
be modified according to symmetry, complexity, and truth
value. But only contingent explanatory theoretical sentences can be modified according to time and certainty.

One way of relating explanatory theoretical sentences is deductively. For sentences to be deductively related
they must form an axiomatic system, A, in which for each possible interpretation can be viewed as stipulative,
which makes the axioms (postulates, P) true, every theorem, T, likewise is true. The relationship that holds between the postulates and the theorems is that of implication.

An axiomatic system, A, is a subsystem of some lan-
guage, L, such that some permissible or well-formed formu-
ations, wfs, of L are undecorated (are equations, P's) with
respect to rules of transformation, G, and from which by
appication of G, theorems (T's) are derivable.

Notice that in an axiomatic system all the sentences
can be separated into two sets: a set of undecorated
sentences (P's) and a set of derived sentences (T's). The
undecorated sentences are necessary to prevent circularity,
and the derived sentences must be derived from the postu-
lates or other theorems.

One subset of the transformation rules (G's) is con-
stituted by replacement rules (definitions, D) establishing
synonyms. This is a metatheoretical view of definitions. The
theoretical view is that definitions constitute descript-
ive metaphysics. That is to say, on the theoretical level,
a definition describes properties of the definitions. In the
metatheoretical level, the definiendum is an abbrevi-
ation for the definition. The descriptive definition becomes
an abbreviation of which states a rule for substituting
fewer terms for more terms. Rules are stipulations (demands
for agreement) which are conventions (agreements) such that
any definition can be viewed as stipulative and conven-
tional. However, this does not make a definition arbitrary,
since the metatheoretical has a basis in the theoretical.

The language, L, of which the axiomatic system, A, is a
part, as all languages, has elements, a vocabulary, V, and

rules, a grammar, G. Given V and G, L can be generated.

The vocabulary consists of primitive terms (undefined
terms, $V_U$) and defined terms, $V_D$. There must be primitive
terms to eliminate circularity. The vocabulary is set forth
in descriptive metaphysics.

The grammar consists of syntactical rules, G, which
are rules for form, and semantic rules, S, which are
rules for content. Of course, L must be interpreted, as it
is in all theory other than formal theory, in order to have
meaning. We have already noted the subset of G, the trans-
formation rules, G, which include the replacement rules, D.
The other subset of G is the formation rules, G'. These
rules determine the well-formed formulas of the lan-
guage, L.

The calculus, C, is an uninterpreted (purely formal)
axiomatic system, A. A simplified example of a calculus of
a deductive system would be the set of postulates:

\[
P_1: A \rightarrow B
\]

\[
P_2: B \rightarrow C
\]

\[
P_3: D \rightarrow C
\]

Some of the theorems would be:

\[
T_1: B \rightarrow D
\]

\[
T_2: A \rightarrow C
\]

\[
T_3: A \rightarrow D
\]

$T_1$ can be derived from $P_2$ and $P_3$:

\[1. \quad A \rightarrow B \rightarrow C \rightarrow D \rightarrow C \quad P_2, P_3\]

\[2. \quad B \rightarrow D \quad (1) \quad TF\]

\[3. \quad B \rightarrow C \rightarrow D \rightarrow C \rightarrow B \rightarrow D \quad (1) \quad TF\]

$T_2$ can be derived from $P_1$ and $P_2$:

\[1. \quad A \rightarrow B \rightarrow C \rightarrow P_1, P_2\]

\[2. \quad A \rightarrow C \quad (1) \quad TF\]
Zetterberg has given an interpretation of the calculus in terms of certain social phenomena. To give an interpretation of the calculus in terms of social phenomena that are educational one would have to interpret the determinants and resultants in terms of properties of teacher or student or learning content or teaching context or teaching-student chain of transformation rules, etc. The particular rule being applied here is

$$p ightarrow q; q ightarrow r; r ightarrow p$$

Zetterberg in ON THEOREY AND VERIFICATION IN SOCIOLOGY sets forth a deductive relation of explanatory theoretical sentences in which the above calculus can be discerned. Taking the following theoretical sentences as given:

1. National prosperity (A) produces middle class expansion (B)
2. B produces consensus of values (C)
3. B produces social mobility (D)
4. D produces C and vice versa

he sorts out 1, 2, and 4 as postulates. The postulates are then the same as in the calculus stated above, namely

I. A → B
II. B → C
III. D → C

He then uses Postulates II and III to derive 1, B → D, and so orders it under the postulate as a theorem in the system. He then goes on to derive A → C, using Postulates I and II, and A → D, using Postulates I and the first theorem he derived, B → D. (The three derivations of Zetterberg are presented above in the calculus.) Thus, two other theorems emerge and are ordered under the postulates and the first stated theorem. All six theoretical sentences thereby are related deductively.

An example of an inventory of resultants is found in G. Maccia's and my theorizing about education as a social system (MAN IN SYSTEMS, 1977) in which the following explanatory theoretical sentences were related:

Centralization (CE) in an educational system leads to no demand (TP) placed upon that educational system.
CE in an educational system leads to standardization (IM) within that educational system.
CE in an educational system and stress (SE) on that educational system leads to no stability (SB) in that educational system.
CE in an educational system leads to independence of parts (I) within that educational system.

From the examples of the digraphs, it is clear that digraphs may present relations between modified explanatory theoretical sentences. The digraph which relates Zetterberg's explanatory theoretical sentences includes one that incorporates a symmetrical connection among the others which incorporate asymmetrical connections.

The digraph which relates the explanatory theoretical sentences from Maccia's and my theory includes the truth values of the determinants and resultants. Agreement in truth value between the pairs gives a positive connection (indicated by an arrow with a solid shaft) while disagreement between pairs a negative connection (indicated by an arrow with a non-solid shaft).

Moreover, the digraph representing the inventory of CE's resultants also incorporates a complex determinant which consists of conjuncts, centralization, CE, and stress, SE, which together produce no stability, SB. If the digraph incorporates a complex determinant or resultants which consists of disjuncts, then the digraph would have to be
represented differently, for one or any combination of the
distincts could produce the effect. Mullins in HIS ART OF
THEORY presents such a digraph from Berson and Steiner's
Theory of Organization.

Communication Channels

Decentralization

Similarity

Schema 21: A Digraph Which Represents Disjuncts

To summarize this section on explicating the explana-
tory theoretical sentences, the following steps are involved in
ordering the sentences:
1. sort out the explanatory theoretical sentences
   from the descriptive theoretical sentences;
2. sort the explanatory theoretical sentences
   according to the following categories:
      philosophical, scientific, and praxiological,
      and
3. deductively or digraphically order the
   explanatory sentences within each category.

Since the function of theory is to present knowledge
of universals, the worth considered here will be epistemic.
Theories are selected as the basis of truth. Aquinas
presented a succinct definition of truth: "Veritas est ade-
quamvis rel ad intellectum." (De Veritate, Q. 1, A. 1) Al-
though the literal translation of the Latm is "truth is the ade-
quamation of things and the intellect," perhaps it is better
understood as truth is the correspondence of our beliefs to
reality. In the words of Aristotle: "To say of what is
that it is not, or of what is not that it is, is false:
while to say of what is that it is not is not that it is not,
it is true." (Metaphysics 1011b 26 ff.)

Because of the fallibility of human beings, it should be
obvious that they could err at any one time as to what
beliefs are to be counted as true. For example, earlier the
Philosophical Theory was true for Aristotle. The lack of oxygen
not paloagia--a supposed volatile constituent of all com-
 bustible substances--is involved in burning. Another exam-
ple is that predated Copernicus (1473 - 1543) would be the
Pythagorean Theory which made the earth the center of the
universe. Human error does not mean there is no truth or human

beings cannot know what is true. There is advancement in
theoretical knowledge.

Perhaps it is not as obvious that human fallibility
produces disagreement at a given time as to the truth. Con-
sider the disagreement between Beirch and Freud about the na-
ture of the unconscious. Beirch claimed that what Freud pre-
sented as the unconscious--the basic sexual and aggressive
nature of the human being--was not primary but secondary, a
defamation of a basic social and non-aggressive human na-
ture. What is necessary to settle this disagreement is more
phenomenological analysis, analysis that is yet to be done.
Human disagreement does not mean that there is no truth or
human beings cannot know what is true. There will be advan-
tage in human knowledge.

Human fallibility, thus, results in emergent truth for
human beings. In other words, the human being does not pos-
sess an unlimited truth. Since 'absolute' comes from the
Latin absolutus meaning completed or unconditional, truth
that is unlimited is absolute truth. It is truth with a 'T'
or it is Truth which some call 'God'. As Peirce stated:
"If belief were to tend indefinitely toward absolute
fidelity," we would have the Truth. ('What Pragmatism Is')

A caveat is in order. Because some human beings do not
or will not accept the truth as set forth by human beings
who inquire does not mean that there are multiple realities
and so their beliefs correspond to their own realities which
differ from the reality of inquirers. This way of putting
the matter is wrong. There are not multiple realities only
multiple views of reality. What such non-acceptance means
is that they neither are or will be inquirers nor will they
accept the results of inquiry. It means that they refuse to
be rational and to listen to reason. They refuse to follow
or acknowledge the method in which beliefs are made explicit
and public and are justified by stating reasons supporting
the beliefs.

In 1878, Peirce published a paper, "The Fixation of
Beliefs", in which he introduced the word 'inquiry' to sig-
nify the rational way to settle doubt and so to fixate
belief. The rational way to settle doubt is a way which is
guided by criteria for seeking truth, i.e., for seeking the
one true opinion on some subject. Peirce acknowledged, ho-
ever, that most persons employ not the method of inquiry but
that of tenacity or authority or 'agreement to reason',
for few persons are possessed by the 'will to learn'. In
the method of tenacity, human willfulness settles the doubt.

Rather than a settlement on an objective basis, there is a
shuffling out from all influences so as to remain settled in
a belief. Peirce is in the essence of the method of authority
the test is what the leader thinks. Preference is the basis
of agreements to reason or what Peirce called the 'a
priori method'; what the reason inlines to the reason
claims.

Peirce used 'scientific' for 'rational', but 'scientific' was used by him in its earlier sense. As al-
ready discussed, in his later work he encompassed all
of theoretical knowledge including philosophy. There-
fore, it would be a mistake to narrow the method of inquiry
to that which is appropriate in its contemporary
sense. Also Peirce used 'a priori' not in its deductive but
in its self-evident sense. In its deductive sense, the a
priori analytic sense. So, even though pragmatics does treat
of the relation of language to language user in so far as it
treats of functions of language, it does not treat of pur-
puses of the language user except as the language user's

Given that theories are selected on the basis of truth,
the evaluation of a theory takes the following form:

T is w because of r

where 'T' stands for a theory
'w' stands for true or false
'r' stands for reasons that refer to the theory itself.

Since explication of the theory should provide the rea-
sions why a theory is true or false, Peirce's theory must be
in the context of epistemic criticism. To be in such a con-
text is to test an underpinning of the language which is the
theory so that the expression of beliefs about reality is
revealed. The methods of explication that I presented do
just that.

To explicate language is to present the order which is
the language. The order of language is constituted by its
pragmatics, semantics, and syntax. It comes from the
Greek 'praktikos' to do, and so pragmatics treats what
the language is doing, its function.

'Pragmatics' here is not used in a behavioral sense but
in an analytic sense. So, even though pragmatics does treat

The last section set forth the first set of methods in
criticizing theory, explanation. Now I shall consider the
second set of methods which are the heart of criticism.

'Criticism' comes from the Greek 'kritikos' meaning to
separate out or to select. The essence of the act of crit-
icism of a theory then must be a judgment of a theory as to
its worth. Obviously, theories are not selected unless they
are of worth.

To judge a theory as to its worth demands that one
first has a clear grasp of what kind of worth is being con-
sidered. Is the worth intrinsic or instrumental? If it is
intrinsic worth, is it either epistemic or moral or aes-
thetic worth? If it is epistemic worth, then truth is being
considered. If it is moral worth, then goodness is being
considered. If it is aesthetic worth, then beauty is being
considered. If it is instrumental worth, then utility is
being considered.

4. EVALUATING THEORY
If the teacher-student ratio decreases then the frequency of teacher-student interaction increases by the syntactical rules, transposition and hypothetical syllogism. To state the matter more adequately:

1. \( p \lor q \)
2. \( r \lor p \)
3. \( q \supset p \) (1) Trans.
4. \( q \equiv p \) (2) Trans.
5. \( q \lor q \equiv (3) \) (4) H.S.
6. \( r \lor q \equiv (3) \) Trans.
7. \( p \lor q \equiv r \lor p \equiv r \lor q \)

where \( p \) stands for the frequency of teacher-student interaction increases.

Another way of stating that one is presenting the order of language is to say that one is presenting the logic of language.Logic here is not used in a narrow sense where reference is only made to form, to syntax.

To illustrate the concern in narrow logic with only arrangement in language, recall that the commonplace notion of logic takes it to be the study of valid argument forms. When an argument is valid in form, the conclusions follow from the premises or premises, i.e., the sentences are so arranged that one or more sentences are derivable from one or more other sentences according to a rule or rules (called transformation rules—a kind of syntactical rule). Being more specific, the sentence

if the teacher-student ratio decreases then teacher-student liking increases

follows from the sentences

if the frequency of teacher-student interaction increases then teacher-student liking increases

ent knowledge of universals, such language will present reality and thus be true or have epistemic worth. In order to do so function, either is not in certain criteria with respect to form and content, i.e., theory must meet certain syntactic and semantic criteria. The meeting of these criteria constitute the reasons for claiming that the theory is true or has epistemic worth. The process of evaluation then is checking the theory against the appropriate syntactic and semantic criteria. The remainder of this section on evaluating theory will present these criteria.

In explicatory theory, it was discovered that when one nests the terms of the theory and their definitions, descriptive metaphysics is being presented. Descriptive metaphysics, as was stated earlier, is a set of interrelated theoretical sentences which describe the properties of a system, and such description may be either a structural or a state description. The first set of criteria, therefore, will be those that must be met if descriptive metaphysics is to be true and so of epistemic worth.

Descriptive metaphysics is a division of the phenomena which are the object of theorizing—the system—so that a set of descriptors characterizing the system’s properties emerges. To do this, the metaphysician must provide a set of class terms for characterizing each and every component of the system. As already noted, a class term is used for predication of a property, since such predication is recognition that the component is a member of a certain class. Therefore, classification is basic to descriptive metaphysics.

However, classification always involves definition. A class term denotes all the particulars to which the term is applicable. The extension of the term denotes and connotes the characteristics that a particular must have in order for the term to be applicable to it (the intensity of the term). Since extension is determined by intension and a definition sets forth the intensity of a term, definition is basic to classification.

What then are the criteria for a classification which is of epistemic worth? The criteria are exactness, exclusivity of exhaustiveness, external coherence, and extendability.

The criterion of exactness demands that the class terms be well-defined. A true definition states the universe (gama) from which to sort out classes, and the differences

or essential characteristics (differential) which distinguish the class being sorted out from the other classes in the universe. For example, the following definition

Education is intended guided learning

sets forth learning as the gama and intended guided as the differential. This definition can be presented through the schema:

Learning education intended guided

To determine whether the above definition of ‘education’ meets the exactness criterion one can use the method of comparative variation. In this method, one does not appeal to observation nor does one regard a property as essential, rather one inquires into the essentiality of properties by taking an example and asking whether without each of its properties it could be recognized as an example of a certain kind of object. Relating this to the above definition of ‘education’ one can take an example such as Johnny being educated in reading and ask whether without Johnny being guided to learn to read could the example be recognized as education.

An example of a definition of ‘education’ which does not meet the criterion of exactness is John Dewey’s. He conceived “education as the process of forming dispositions, intellectual and emotional toward nature and fellow men” (DEMOCRACY AND EDUCATION, p.383). Education encompassed too much; it became as broad as human learning, as human being in the world. His definition lacked the essential property of learning that is guided.

The attempt to apply the criterion of exactness has made apparent that adequacy of a definition depends upon classification. The definition of ‘education’ depends upon sorting out education from other classes of learning. Dewey can be faulted only if the kinds of human learning are considered.
The criteria of exclusivity and exhaustiveness can be stated with precision through set theoretic concepts. Classes can be viewed as subsets of the universe which is taken as the universal set. Within the context of such viewing, the criteria of exclusivity and exhaustiveness can be stated as follows.

**Exclusivity:** Every element in the given universe appears in at most one subclass, i.e., \( S_1 \cap S_2 = \emptyset \) for every pair of subclasses under consideration.

**Exhaustiveness:** Every element in the given universe should be in some subclass, i.e., \( \exists S; S \subseteq U \), where \( S \); \( S \subseteq U \) and the collection of subclasses and union is performed over all subclasses.

Exclusivity and exhaustiveness together require that every element of the universe appears in at most one subclass \( S \).

An example would be the classification of learning (L) into fortuitous learning—non-intended and non-guided—(F), training—non-intended and guided—(T), discovery—intended and non-guided—(D), and motivation—intended and guided—(E). Schema 25 represents this classification.

<table>
<thead>
<tr>
<th>F</th>
<th>T</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
</table>

**Schema 25: Classes of Learning**

To apply the criteria of exclusivity and exhaustiveness, one can use the method of imaginative completion. What one does is to search for components of the system which are not classified, i.e., which do not appear in at most one subclass \( S \).

An example of an inadequate classification of cognitive educational objectives would be that of Bloom. Bloom sorts the cognitive educational objectives into knowledge and intellectual abilities and skills; as he defines it, "involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, value or setting" (1964, p. 131). However, intellectual abilities and skills emphasize the mental processes of organizing and reorganizing material to achieve a particular purpose" (ibid., p. 189). The method of imaginative completion does not have to be carried out too long to discover components which do not belong into two classes, KNOWLEDGE and INTELLECTUAL ABILITIES AND SKILLS. Then KNOWLEDGE is subdivided into three subclasses: KNOWLEDGE OF FACTS AND MEANS OF DEALING WITH SPECIFICS, and KNOWLEDGE OF THE UNIVERSALS AND ABSTRACTIONS IN A FIELD. Then KNOWLEDGE OF SPECIFICS is subdivided into two classes: KNOWLEDGE OF DETAILS AND MEANS OF DEALING WITH SPECIFICS into five classes; and KNOWLEDGE OF THE UNIVERSALS AND ABSTRACTIONS IN A FIELD into two classes. The same kind of subdividing occurs with respect to INTELLECTUAL ABILITIES AND SKILLS, only different samplers of subdivisions are involved. INTELLECTUAL ABILITIES AND SKILLS is subdivided into three classes: APPLICATION into two classes; and SYNTHESIS into three classes; EVALUATION into two classes; and APPLICATION is not subdivided.

For a classification to be a taxonomy, it must meet the criterion of hierarchical order. To be hierarchically ordered a classification must meet the following conditions which I stated earlier still shall repeat here in a different but perhaps more precise form.

1. **Taxa (classes) are arranged in levels which are serially ordered from 1 to n.** Thus, every taxon can be designated by \( T_j \) where the subscript \( j \) indicates the particular level or rank of the taxon. The subscript \( j \) is arbitrarily assigned to differentiate the taxa as a given level.

2. **Every taxon of level \( j \) where \( j < n \) is included in some taxon of level \( j + 1 \).** Stated more precisely, for a given \( j \) where \( j < n \), there exists some \( j \) such that \( T_j \) is included in \( T_{km} \) for \( m = \sum_{i=1}^{j} i \).

3. **The number of taxa of rank \( j \) is greater than the number of taxa of rank \( j + 1 \).**

Bloom's classification meets at least the first three conditions. The lowest level of his classification is 1 and the highest level \( n \). Subclasses which are both taxa of level 1. Moreover, every taxa of rank 1 \( 1 \) contained in a taxa of rank 2. Every taxa of level 1 is contained in a taxa of rank 2. Finally, on level 3, there are 2 classes; on level 2, 9 classes; and on level 1, 21 classes. As to the taxa of each rank being mutually exclusive and exhaustive, there are difficulties. An example would be the separation of analysis of relationships and the analysis of organizational principles into two classes. Surely the relationships are the structure that hold the communication together, and so to analyze one is to analyze the other.

The criterion of external coherence demands that the classification fit in with extant theoretical knowledge. For a theoretical statement to fit in with extant theoretical knowledge, the theoretical statement must be a member of the present system of true theoretical statements whose elements are related by ties of logical implication.

Logical implication is best understood in terms of logical consequence. A statement is a logical consequence of another statement if and only if by logical implication when one statement, \( S' \), is a logical consequence of the other, \( S \). To be a logical consequence means, of course, that \( S \) can be logically derived from \( S' \). This can be done by forming a conditional in which \( S' \) is the antecedent and \( S \) is the consequent and then determining if this conditional is valid (true under all interpretations). If and only if the conditional is valid, is \( S \) a logical implication. The reason for this is that the case in which the antecedent is true and the consequent is false is ruled out. This would be the only case in which the condition is met but the consequent is false. So \( S' \) must logically follow from \( S \), and so is \( S \). To summarize: for a statement \( S' \) to imply another statement \( S \), no interpretation of truth values can make \( S' \) true and \( S \) false.

To have an example of failure to meet the criterion of external coherence, consider once again Bloom's taxonomy of educational objectives. Bloom introduced a threefold division of educational objectives: cognitive, affective, and psychomotor. Cognitive educational objectives are those for development of thought structures and affective educational objectives were those for development of feeling structures, while psychomotor educational objectives were structures for human action where the body was involved. This division, however, is invalid in view of the extant theoretical knowledge. This knowledge is not to be found in psychological psychology, and some was developed long ago by Plato.

Plato, in the Republic and elsewhere is his writings, sets forth the threefold division of the human psyche: thinking, willing, and feeling. Bloom neglects willing conative educational objectives for development of willing structures are not presented. Also psychomotor educational objectives are based on Bloom upon a separation of human actions into those in which only mind is involved and those in which both body and mind are involved. This separation does not fit with the knowledge that we have about human action. There may be difficulty in coming to know how the mind and body are involved in every human action, but that body and mind are both involved in every human action is not problematic. The cognitive, conative, and affective structures are all structures for acting. Whatever there is of human acting, there is both mind and body. To be more specific, the solution of a mathematical problem is as much a bodily action as cognitive activity. Further, educational objectives for developing structures for handwriting fall into the same domain of educational objectives as do educational objectives for solving mathematical problems; they fall into the cognitive domain.

To summarize this example of failure to meet the criterion of coherence, the statement

If educational objective then either cognitive or affective or psychomotor

does not follow logically from the statement

If psychomathematical development then either cognitive or conative or affective, and if educational objective then psychomathematical development.
That is the schema

\[ p \rightarrow q \land r \land s \land t \rightarrow q \land v \land u \]

where ‘p’ stands for psychological development, ‘q’ stands for cognitive, ‘r’ stands for conative, ‘s’ stands for affective, ‘t’ stands for educational objective, and ‘u’ stands for psychomotor.

is not valid; it does not come out true given the consequent is false. So we have a case where the antecedent is true and the consequent is false. There is no logical implication.

The final criterion that of extendibility demands that terms can be added to the theory to describe a greater range of phenomena. To meet this criterion, generality in description is required. For example, Bloom did begin his description at the most general level. He did subdivide the entire domain of educational objectives although not adequately. Thus, he put the field in a position to extend the description beyond his first taxonomy which was of the cognitive domain. His group went on to develop the affective domain, but they did not go on to develop the psychomotor domain. Others have attempted this development.

The above criteria for descriptive theory—exactness, exclusivity, exhaustiveness, external coherence, and extendibility—are semantical ones. They are criteria for content. The next set of criteria will be syntactical—criteria for form. The criteria are equivalence, chaining, and substitution.

To meet the criterion of equivalence, all the descriptive theoretical propositions of the theory should be capable of explication as definitions with each definition in the form of a replacement rule:

\[ \text{definiendum} \rightarrow \text{definiens} \]

where ‘definiendum’ stands for the term to be defined, ‘definiens’ stands for the term or terms that are logically equivalent to the definiendum and the definiens.

The criteron of chaining is as follows: the definitions can be explicated so that the definiens of one definition becomes the definiendum of the next definition.

The criterion of substitution is as follows: the terms of definitions must constitute two subsets—undefined (primitive) and defined—and undefined terms must be substitutable for defined terms in each definiens.

Hempel, a contemporary philosopher of science, gives a more rigorous expression to the above two rules in his requirement of univocal eliminability of defined expressions.

Requirement of univocal eliminability of defined expressions:

For every sentence S containing defined expressions, there must exist an essentially unique expansion in primitive terms, i.e., a sentence S’ which satisfies the following conditions: (1) S’ contains no defined term; (2) S’ and S are derivable from one another with the help of the definition chains for the defined expressions occurring in S; (3) if S’ is another sentence which, in the sense of (2), is definitionally equivalent with S, then S’ and S are logically deducible from each other and thus logically equivalent. (pp. 17-18)

The following set of definitions is an illustration of a definitional system and of one that meets Hempel’s requirement.

1. Rxy =Df Syx
2. Txy =Df Fx • Rxy
3. Uxy =Df Rxy • ¬Txy
4. Vxy =Df (Ez)(Rzx • Ray)
5. Wxy =Df ¬Fx • Vxy

Since logical equivalence is mutual implication, it can be checked as one checks implication, only it must be checked by means of two conditionals not one. In one conditional, the definiendum must be the antecedent and in the other it must be the consequent.

Another way of viewing the definition is a statement setting forth the necessary and sufficient conditions in the definiens (Dm) for using the definiendum (Dm) to refer. In other words, the form becomes

If and only if Dm then Ds,

which is logically equivalent to

If not Ds then not Dm, and if Ds then Dm.

The first conjunct sets forth Ds as a necessary condition for Dm (without Ds you cannot have Dm), while the second conjunct sets forth Ds as a sufficient condition for Dm (Ds can give Dm).

To illustrate, the description of learning as psychological development was stated as a rule of replacement in the section on explicating theory.

Learning “p” psychological development

This can be stated also as

If not psychological development then not learning, and if psychological development then learning.

Psychological development is both a necessary and a sufficient condition for someone to have learned (for using ‘learning’ to refer).

Notice that definitions are not arbitrary; they are formulated from descriptive theory. But there is a sense in which definitions are stipulative and conventional. It is patent that all language is stipulative. There is no necessity of relation between the word selected to refer to learning and learning. The relation is stipulated by the developer of language. One could introduce ‘teaching’ instead of ‘learning’ to refer to psychical development. Such introduction would not be adequate. Stipulations of theoretical language should be governed by the conventions of the language of extant knowledge. One should not make stipulations which are antithetical to extant knowledge. For the adva
exhaustiveness  
is external coherence  
syntactic equivalence  
chaining  
substitution

Thus to evaluate descriptive theory, one must judge it according to the above criteria. That is to say, one can conclude that descriptive theory is true provided one can give reasons why its content is adequate—once one can state that its content meets the above semantic requirements—and one can give reasons why its form is adequate—one can state that its form meets the above syntactic requirements.

Given descriptive metaphysics which is knowledge (is true for the reasons as explicated in the semantic and syntactic criteria stated above), there is an adequate foundation upon which to build explanatory theory. Unless there is a true description of properties, one has no basis for attempting to set forth a true description of the relations between properties. Attempts to describe relations between unknowns surely are doomed to failure.

Husserl (1859-1938) pointed out the need for an adequate foundation for psychological explanatory theorizing.

... A really adequate empirical science of psychical in its relations to nature can be realized only when psychology is constructed on the basis of a systematic phenomenology. It will be, when the essential forms of consciousness and of its immanent correlates, investigated and fixed in systematic connection on a basis of pure intuition, provide the norms for determining the scientific savage and content proper to the concept of any phenomena whatever, and hence proper to the concepts whereby the empirical psychologist expresses itself in his psycho-physical judgments. (pp. 119-120)

To state the matter differently, the terms which stand for the properties being related must be well-defined. To be well-defined means that the terms must be estranged (philosophical theoretical sentences) must be considered separately from those which express contingent relations (scientist and praxiological theoretical sentences). Since necessary relations between the determinants and resultant are those that are essential and so arise from the very nature of the determinants and resultant, given the nature of the determinants and resultant the connections between them is a matter of logical implication. Logical implication is, as stated above, logical consequence.

To illustrate, I shall utilize the example presented in explicating necessary relations. Liberal content of education can be related as a resultant to the determinant, student achievement objective of autonomy. Because such a relation is necessary. To establish that this is so, it can be shown that liberal content of education is a logical consequence of student achievement objective of autonomy.

Student achievement objective of autonomy (symbolized by p) is psychical development of a person intending to learn under guidance in which the student becomes a decision-maker (symbolized by q). q is to be one who can make judgments (symbolized by r). For r, one must have knowledge (symbolized by s). Thus, s is a logical consequence of p. The deduction is

1. q ≡ r  
2. r ≡ s  
3. q ≡ s  
4. q ⊃ r  

Given that s is a logical consequence of q and p is equivalent to q, it follows that s is a logical consequence of p. The deduction is

1. q ≡ s  
2. p ⊃ q  
3. p ≡ s  
4. q ⊃ p  

Since to have liberal content of education (r) is equivalent to having knowledge and since having knowledge is a logical consequence of student achievement objective of autonomy, liberal content of education is a resultant of the determinant, student achievement objective of autonomy. The deduction is

1. r ≡ s  
2. p ⊃ r  
3. r ≡ t  
4. r ⊃ t  

Of course, the establishment of the necessary relation ultimately depends upon whether the determinant and resultant terminate upon intuition which is the essential autovivis. The essence of the content of liberal education is taken to be knowledge. That these are adequate definitions is shown in the analysis presented in EDUCOLOGY OF THE FREE. In that work, I showed why knowledge should not be used in the sense of only quantitative knowledge, as Bloom uses it, and why it should be extended to include qualitative and performative knowledge.

To summarize, the semantic criterion for philosophical theoretical sentences that are explanatory is correspondence to necessary relations between properties.

The situation changes when one considers the content of scientific and praxiological theoretical sentences. This content must correspond to contingent relations between properties, i.e., the criterion is correspondence to contingent relations between properties.

To justify contingent relations, techniques other than logical are required. Observational techniques are required to determine correspondence. Such observational techniques are what have become known as 'empirical research'. However, that is an undue limitation of the use of that phrase which limitation is rooted in 18th Century Empiricism. Experience is not just a matter of sensory observation. If it were, no descriptive metaphysics would be possible and so grounding of explanatory theory. Descriptive metaphysics depends upon intuition which is an intellectual observation. Then too philosophical explanatory theory would not be possible. Philosophical explanatory theory sets forth necessary conditions which are not a matter of sensory observation. These connections are non-sensible, and so for the
positivists and logical empiricists would be nonsense. Thus, positivism and its 20th Century descendant, logical empiricism, are inadequate epistemological positions.

If the establishment of relations between variables through observational techniques establishes contingent relations between properties, variables with respect to properties must be considered. Properties can be related through variables that may be a symbol for a set of values which can be associated with the property, and if instances can be placed in the set of values, there the variables are contected to it. If two or more sets of values to which properties are connected can be related, then contingent relations of reality can be established.

'Reality' here is not used in the sense of objects outside of and rather in the sense of objects appearing to human beings. No position is taken about independent reality, and so absolute truth is not involved. To go beyond phenomena, depends upon yes-no thinking beyond the methods embodied in our knowledge of theory construction.

To determine whether instances can be placed in a set of values associated with the property, a procedure of observation is necessary. This procedure is known as the instrument or indicator which may or may not involve the extension of the senses. For example, the student property, university achievement, is associated with a set of values known as grade-point average. The values are obtained by assigning weights of 4, 3, 2, 1, and 0 to grades of A, B, C, D, and F, respectively. These weights are obtained by the procedures of the professor in each course through which student performance is observed. Instruments or indicators, such as tests, are used. These instruments do not involve the extension of the senses, as, for example, the lie detector (polygraph).

The instruments, of course, must be valid. They must permit observation of what they purport to observe. Unless the student property, university achievement, is defined, there does not exist a basis for devising the instrument. Thus, specification of indicators cannot take the place of theoretical definitions, even though such specifications be called 'operational definitions'. Construct validity—whether the instrument is permitting observation of the property—is a matter of the multiplicity of instances. Whether an instrument sorts out instances in terms of values is not enough to establish validity. The values must be associated with a known property. As Jetterberg states it:

They [definitions and indicators] should... embrace each other in the most intimate way. When we ask how 'valid' the indicators are, we are asking about the intimacy of this embrace. (p. 113)

Operationalism in which the so-called operational definitions are taken as sufficient is atheoretical in approach. Variables are substituted for properties. In fact, 'variable' has come to be used for 'property', even when someone accepts theoretical definition as Jetterberg does.

One may here question the place of operationalism in sociology. It is suggested that operationalism concerns the definitions of score values on variable. When we are asked, not what variable a man experiences, but what a certain score on this scale signifies, we give our answer in terms of a description of the scoring technique, the standardization group, and so forth—i.e., an operational definition. (p. 113)

It is to be noted that a variable is simply a set of values and so what variable reduces to what values.

Given valid (and of course also reliable) instruments for two or more properties, data can be collected. If the data collected establish a relation between the two or more variables associated with the properties, then contingent relations are established.

However, not all the properties expressed by the terms in scientific or praxiological sentences can be associated directly with variables. Some properties can be associated only indirectly with variables insofar as they are related to properties that are directly associated with variables. The property fit is a matter of relations between properties, some of which can be directly related to data. For example, in Freud's theory, compulsion is a property that is observable only in the relation to some property, while an unconscious desire is not. But the unconscious desire can be related to repression which in turn can be related to compulsion. One property does not directly associate with variables; thus, if one accepts operationalism, then all properties that are not directly associated with variables would be meaningless.

within reality are philosophical. However, it should be noted that Spinoza, who is following Aristotle's lead, took the presentation of theory in categorical axiomatic form to be the proper form for all knowledge about reality.

The deficiency of operationalism with respect to completeness is brought forth through its emphasis on empirical phenomena and its neglect of deductive theoretical thinking. Explanatory theory, whether it be philosophical or scientific or praxiological, must set forth all the relations between its premises. Thus do the terms 'categorical', 'axiomatic', and 'theorizing. Explanatory theory must meet the criterion of completeness.

Since the content of theory goes beyond sentences to their interpretation, a criterion relative to the systematic nature of theory also must be met. This criterion is coherence. 'Coherence' comes from the Latin 'cohearent', meaning to cling together. This means systematic as if the sentences through which it is expressed cling together. What is meant by clinging together needs further precision.

Within logic, coherence means that sentences are related by implication. Coherence as logical implication cannot be shown, however, unless the elements of the system are put into an axiomatic system. To put sentences into an axiomatic system is to arrange them so that some are posited as axioms from which all the others, the theorems, and deductions, FOLLOW.

There are different kinds of axiomatic systems. The categorical and the hypothetical are the two basic kinds.

In the categorical axiomatic system, the truth of the theorems is demonstrated by the truth of the axioms. The evidence supporting the truth of the axioms is transferred to the truth of the theorems. The evidence for the connection of the axioms and the theorems and in the very posing of the axioms. There are no qualifications with respect to the truth of the axioms. A famous example is Spinoza's system of ethics presented in his ETHICA ORDIN GEOMETRIC DEMONSTRATA (1677).

Theoretical systems which describe necessary relations
AND MAGNETISM (1873).

Not only these scientific theories but all other scientific theories and praxiological theories (all theories of contingent relations) are expressible as hypothetical axiomatic systems. Another term for hypothetical axiomatic systems is ‘hypothetic-deontic system’. That is why in the literature, one finds reference to science as hypothetic-deontic in nature.

Schema 26 summarizes the kinds of axiomatic systems relative to the kinds of theory.

\[
\begin{align*}
\text{CATEGORICAL} & \quad \text{PHILOSOPHICAL} \\
\text{AXIOMATIC} & \quad \text{LOGICAL} \\
\text{HYPOTHETICAL} & \quad \text{MATHEMATICAL} \\
\text{FORMAL} & \quad \text{THEORY} \\
\text{MATERIAL} & \quad \text{SCIENTIFIC} \\
\text{PRAXIOLOGICAL} & \quad \text{FUNCTIONAL} \\
\end{align*}
\]

Schema 26: Kinds of Axiomatic Systems Relative to Theory

To check out coherence, no matter whether the axiomatic system is categorical or hypothetical, one must determine if there are any contradictions in the system. There will be contradictions in the system if and only if one or more of theorems are not logical consequences of the postulates. To make such a check, the axiomatic system must be explicitly expressed.

An example of a check of a scientific theory for coherence is Maris’ attempt with respect to Homans’ Social Theory. Maris sets forth a theory of social behavior based upon notions about how human behavior is developed and what profit is. He took human behavior to be developed through differential reinforcement and profit to be reward minus cost.

Maris sets forth Homans’ postulates as

P1. If in the past the occurrence of a particular stimulus-situation has been the occasion on which a man’s activity has been rewarded, then the more similar the present stimulus-situation is to the past one, the more likely he is to emit the activity, or some similar activity now.

P2. The more often within a given period of time a man’s activity rewards the activity of any other, the more often the other will emit the activity.

P3. The more valuable to a man a unit of the activity another gives him, the more often he will emit activity rewarded by the activity of the other.

P4. The more often a man has in the recent past received a rewarding activity from another, the less valuable any further unit of that activity becomes to him.

P5. The more to a man’s disadvantage the rule of distributive justice fails of realization, the more likely he is to display the emotional behavior we call anger.

Maris goes on to list Homans’ research findings as twenty-five points to check out whether the theorems can be logically deduced from the postulates and concludes that they can. The check should be made through truth functional and quantification syntactics which is summarized in Appendix I.

To illustrate an adequate check, Maris rightly deduces what he calls ‘Theorem 2’ from Postulate 2. Theorem 2 is

The more valuable to Person the activity he gets or expects to get from Other, the more often he emits activity that gets him, or he expects will get him, that reward.

The deduction is

\[
\begin{align*}
1. & \quad p \rightarrow q \\
2. & \quad q \rightarrow r \quad \text{(1) TP} \\
3. & \quad p \rightarrow qr \quad \text{E.A.} \\
\end{align*}
\]

where ‘p’ stands for the Other’s activity

\[
\begin{align*}
\text{q’ stands for the Other’s activity rewards} \\
\text{the Person’s activity rewards} \\
\text{the Other’s activity} \\
\text{the Person’s activity rewards the activity of any Other} \\
\text{the Person’s activity} \\
\text{the Other’s activity} \\
\text{the activity’s function schema, namely,} \\
\text{the Person’s activity} \\
\text{the Other’s activity} \\
\end{align*}
\]

The deduction is erroneous for three reasons. The first reason is that p is not a negation of q, nor is q a negation of q. Maris seems to realize this when he states: ‘The truth values of ‘‘ and ‘‘ are problematic, . . . because in Homans’ work these values tend to empirical disbringments, not simply to logical properties of presence or absence’’ (p. 1072). The solution is to change Postulate 2 by deleting ‘the more often’ so that both more and less would be built into the postulate. This would also take care of the second reason why the deduction is wrong, the use of a rule of empirical association. Such association only can justify contingent relations not necessary ones. The final reason for the faulty deduction is the use of an invalid truth functional schema. I believe this occurs because Postulate 2 is taken to be a statement of an asymmetrical relation when Homans was asserting a symmetrical one.

The correct deduction then would be

\[
\begin{align*}
1. & \quad p \rightarrow q \\
2. & \quad q \rightarrow r \quad \text{(1) TP} \\
3. & \quad p \rightarrow qr \\
\end{align*}
\]

This deduction would make Maris’ conclusion that Theorem 3 can be deduced from Postulate 2 correct. The deduction that Maris presents would not.

Given the explication of a theory as an axiomatic system, there is no doubt that coherence can be checked. However, theory, particularly that about human phenomena, is rarely so explicated or explicable. Partial formalization at the most obtained. Given only partial formalization, checks on logical consistency nevertheless can be made. There are deductive linkages to check out.

If theoretical sentences are ordered only through digraphing, then logical coherence cannot be checked out. However, ordering through digraphing can present an advantage with respect to theory that expresses relations that are contingent and also recursive and asymmetrical. The advantage is the use of path analytic techniques to check out the correspondences of the relations expressed in the theory to those of reality. Path analysis is a procedure for estimating the path coefficients from correlational data using regression techniques.

In the above discussion of coherence, only internal coherence or logical consistency within the theory was discussed. However, external coherence too must obtained. The three theorems be logically consistent with extant knowledge. The exogenous explanatory theory relative to the theory
must be consistent with true explanatory theory. Such
theory is incorporated in research studies, and so the
relevant research must be reviewed.

Both axiomatization and digraphing, because they are
ways of ordering explanatory theoretical sentences, give
evidence of completeness. Gaps in the theory are shown.
Missing deductive linkages are made apparent in the case of
axiomatization, missing connections in the case of digraphs.

In the case of digraphs which can be presented as path
diagrams meeting the requirements for path analysis (the
connections must be asymmetrical), the density and con-
nections of the digraph indicate whether connections are
missing. Density is the number of direct connections over
the number of possible connections. Therefore, density is
given by the following equation:

\[ DC = \frac{D}{N(N-1)} \]

where \( D \) stands for density,
\( DC \) stands for number of direct connections,
\( N \) stands for number of properties

Obviously, less than \( N-1 \) direct connections results in some
properties not being connected. Thus, density cannot fall
below some minimum value.

Connectedness is the number of direct and indirect con-
nections over the number of possible connections. There-
fore, connectedness is given by the following equation:

\[ CC = \frac{C}{N(N-1)} \]

where \( IC \) stand for number of indirect con-
nections.

To illustrate, consider the digraph which sets forth
Hopkins’ ordering of theoretical generalizations about in-
fluence in small groups as presented in Settserberg (p.36).

determinacy, correspondance, coherence, and completeness,
there is one other attribute that is taken to be charac-
teristic of worthwhile theory. That attribute is simplicity.
Simplicity applies not only to explanatory theory which we
are discussing now, but also to descriptive metaphysics
which was discussed earlier.

William of Ockham (c. 1285-1349) set forth an injunc-
tion that entities should not be multiplied unnecessarily.
That injunction has come to be known as Ockham’s razor which
theoricians are to wield. The problem, of course, is what
does it mean to wield the razor. What entities ought not to
be multiplied unnecessarily? It is patent that the entities
must be those of theory: the predicates to express the con-
cepts and the theoretical sentences to express the universal
generalizations. Unless the theoretical sentences and the
predications are systematized, it is difficult to determine
redundancy. In a well- wrought system, there are no unnece-
sary entities. The theorician that formalizes wields Ock-
ham’s razor.

It should be noted that a theory need not be simple in
this logical sense for it to be true. A theory could con-
tain redundancies and still be true.

Before completing this discussion on evaluating theory,
the comparative value of theories will be considered. This
is an important topic, since theory is constructed on the
basis of other theory and through other theory. Often
choices must be made between competing theories.

Sometimes one theory is of as much worth as another
theory, because they are equivalent theories. When theories
are equivalent, they are consistent with each other and have
the same relevance. The relevance of a theory is the range
of experience to which it corresponds; it is the theory’s
comprehensiveness. In equivalent theories the expressions
are different, but they can be reduced to each other through
a set of translation rules which match the expressions in
the two theories.

When theories are not equivalent, one must be chosen
over the other. The criteria for choice are functionality,
and comprehensiveness. To be more precise:

\[ T' \text{ is more adequate than } T \text{ if and only if } \]

1. \( T' \text{ is more functional than } T \) or
2. \( T' \text{ and } T \text{ are both functional but } T' \text{ is more}
comprehensive than } T \)

A theory is functional when it meets the criteria for the
truth of a theory. Only when a theory meets the truth
criteria is the theory knowledge and so fulfills the objec-
tive of theorizing. The theory is functioning as it should.
That is to say,

\[ T' \text{ is more functional than } T \text{ if and only if } \]

1. \( T' \) has more semantic adequacy than \( T \) or
2. \( T' \) has more syntactic adequacy than \( T \)

To be semantically adequate, a theory must meet the semantic
criteria stated as criteria for evaluating theory. To be
syntactically adequate, a theory must meet the syntactic
criteria stated as criteria for evaluating theory.

A theory is comprehensive or more relevant when it is
more general. When a theory is more general, it covers more
of experience. The precise statement would be

\[ T' \text{ is more comprehensive than } T \text{ if and only if } \]

1. \( T' \) is more general than \( T \)

To summarize:

1. when theories are equivalent, they are of equal
worth, and
2. when theories are non-equivalent, the one of
greater worth is more semantically or syntac-
tically adequate or is more general.
5. EMENDING AND EXTENDING THEORY

When I began this exposition of the methodology of theory building, I pointed out that one is not in a position to construct a theory under the conditions given, or to construct a theory and what, if anything, needs to be done to make the theory true in the state. One cannot undertake to set forth a detailed account of it, i.e., through an explanation in which its content and form are set forth. One comes to understand that something needs to be done, and through judgment of it, i.e., evaluation in terms of standards for its content, semantic criteria, and for its form, syntactic criteria, one needs a basis on which to judge whether there will be either to correct or to add to it. Constructive moves in theory building, therefore, are either those of emendation or extension.

Whether one is emending or extending theory, only rational moves can be involved if the constructing is to be adequate. One must think and not feel or will, as Charles Sanders Peirce (1839-1914), the greatest of the American pragmatists, pointed out when he introduced inquiry for the rational way to settle doubt or fixate belief. This thinking, moreover, must meet certain requirements if it is to result in knowledge.

When thinking meets the requirements for knowledge, it takes one of the following forms of reasoning: intuitive, argumentative, deductive, and inductive. From these four forms of reasoning, only one does not enter into theory construction. This form is deduction; always, induction does enter into theory building for it is one form of reasoning involved in reforming theory.

Induction enters into the theory by the principle of decision of inductive and deductive theories. It is a form of reasoning which is taken as a logic of discovery when it is a logic of verification. The method used by the Baconian school is to investigate the observable world and check the theory against this data to see if it is supported or refuted. The philosopher of the Baconian school is a philosopher of induction. In Baconian philosophy, induction is a process of reasoning in which one derives theory from data. This sense comes from the erroneous presentation by the English philosopher Francis Bacon (1561-1626) of the way of discovering truth.

There are and can exist but two ways of investigating and discovering truth. One method is through the senses and particular to the most general axioms; and from them as principles and their supposed undisputable truth derives and divides the axioms. The other constitutes its axioms from the senses and particulars, by ascending continually and gradually, till it finds the most general axioms, which is the true, but unattempted way. (NOVUM ORGANUM, Summary of the Second Part, Aphorism 19)

Each of these two ways begins from the senses and particulars and ends at the greatest generality. But they are immeasurably different; for the one merely touches cursorily the limits of experiment, and particulars, whilst the other runs duly and regularly through them; the one from the outset lays down some abstract and useless generalities, the other gradually closes to those principles which are really the most common in nature. (Ibid., Aphorism 22)

For Bacon, then, experiment is the source of theory not the justification of theory. Induction is erroneously taken as a logic of discovery when it is a logic of verification. The methods used by the Baconian school is to investigate the observable world and check the theory against this data to see if it is supported or refuted. The philosopher of the Baconian school is a philosopher of induction.

The naturalistic and objectivist standpoint which is expressed in Bacon's thought is the source of this erroneous view of the naturalistic standpoint taken as a logic of discovery when it is a logic of verification. The methods used by the Baconian school is to investigate the observable world and check the theory against this data to see if it is supported or refuted. The philosopher of the Baconian school is a philosopher of induction.

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Since in statistical argument the inference is from a number of instances to the whole collection of instances, the conclusion can only be a probability or a statistical argument. Thus, the conclusion is only probable not necessary. The form of the inductive inference makes this clear:

1. A is true of b1, b2, . . . , bn; and
2. b1, b2, . . . , bn are some members of class B;
3. hence, A is true of all members of class B.

Induction as statistical inference rules out spurious sensus of induction. The spurious sensus of induction is a process of reasoning in which one derives theory from data. This sense comes from the erroneous presentation by the English philosopher Francis Bacon (1561-1626) of the way of discovering truth.

In the process of discovering truth, induction is involved in the theory of theory building. It is involved in the theory of discovery as a process of reasoning in which one derives theory from data. This sense comes from the erroneous presentation by the English philosopher Francis Bacon (1561-1626) of the way of discovering truth.

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When we experience, then, what we do is to give significance to phenomena, to what appears to us. We generate indices or icons or symbols and so meaning. Theorizing then is giving this significance to phenomena with its universalism and so is a process in which symbols are generated. Induction enters into that process only to verify what is generated in the name of science or psychology. So induction enters to prevent a giving of inadequate sense or nonsense.

Among the forms of reasoning that do enter into the construction of theory, intuition and deduction are the forms of reasoning that is used to do descriptive metaphysics and so to construct theory which sets forth the properties of a system.

Intuition, in its exoteric sense, is taken to be an irrational process resulting in insight. As an example, women of the western world have had the intuition of seeing into the future. But intuition, however, is a rational power, a form of reasoning, and not a non-discursive; it is a non-inferential form of reasoning.

'Intuition' comes from the Latin verb, 'intueri' meaning to look upon; an intuition is a looking upon for it is an immediate apprehension by the intellect of the nature of objects given as phenomena. Intuition is the direct perception of an object. The observation of an object that is given in experience. Intuition should not be restricted to the sensory, because, besides entities that can be sensed, there are other entities that cannot be sensed, such as entities of the imagination.

Intuition or intellectual observation is specified through phenomenology. Edmond Husserl in his 1913 book, eidetic phenomenology, a method of thought set forth by Edmond Husserl in 1899-1938. Husserl’s phenomenology was in-
zig. 1764) to mean a theory of illusions, since he limited phenomena to the illusory features within human experience. In contrast, Kant, a contemporary of Lambert, used ’phenomena’ in the unlimited sense of whatever appears in experience. According to Kant, phenomena are to be distinguished from noumena which are der Ding an sich (things-in-themselves). Consequently, the notion of a reality which is absolute object is unthinkable as is a consciousness whose job is to perceive the original. In the middle of the nineteenth century, the term ’phenomenology’ was given to the sensory and so experience was restricted to the sensory. Phenomenology became a descriptive study of what is presented to the senses. Peirce did not restrict his own pursuit of what is being in its broadest sense should be included. Husserl too used ’phenomenology’ in this sense. There was no justification for not studying all the objects given as phenomena.

The method of phenomenology can be set forth in terms of rules. The leading rule is back ’zu den Sachen selbst’ (to the things themselves). By things is meant what is given in experience, the phenomena. The intellectual observation of things-in-themselves is the necessary and objective knowledge. Every indirect acquisition of knowledge is a deduction or retrodiction from some other knowledge. If knowledge is the object of knowledge, then the object of knowledge is the object. Phenomenology became a descriptive study of what is given in experience, the phenomena. The intellectual observation of things-in-themselves is the necessary and objective knowledge. Every indirect acquisition of knowledge is a deduction or retrodiction from some other knowledge. If knowledge is the object of knowledge, then the object of knowledge is the object.

The second rule of the method is that the inquirer should focus completely on the object to the exclusion of everything subjective. Of course, the subject must give significance, but this significance cannot be in terms of what is merely of the subject or what is useful for the subject. In order to eliminate what is merely of the subject, e.g., feelings, the inquirer must forget the self completely and intellectually gave only upon the object. In order to eliminate what is useful for the subject, the inquirer must not ask what is useful to himself, what is useful for the object. In other words, the inquirer must take the contemplative standpoint. This rule is not new, for it has governed all philosophical inquiry. It has long been recognized as an essential ingredient of the scientific method. Also it is the rule that assures what has been called ’objectivity’. In every inquirers, ’objectivity’ should not be taken in the sense of eliminating the subject and so consciousness. If so, the rule would be contradictory to the phenomenological method. ’Objectivity’, rather, should be taken in the sense of intersubjectivity.

Two caveats are in order. First, effective and conative states always accompany cognitive states, and so it is impossible for an inquirer to be in a purely cognitive state. In every inquirers, ’objectivity’ should not be taken in the sense of eliminating the subject and so consciousness. If so, the rule would be contradictory to the phenomenological method. ’Objectivity’, rather, should be taken in the sense of intersubjectivity.

The third rule of the phenomenological method is to exclude everything which is not given in the object under inquiry. The known not directly given can be by inference or from other sources. The known through inference can be excluded. Inference is the ground of all deduction and retrodiction can be grounded phenomenologically. Descriptive metaphysics is the grounding required for all deduction and retrodiction. The known not directly given is to be found in the literature. What is asserted by others must never be relied upon as a foundation. Knowledge must be the product of the human mind, as stated above.

The fourth rule of the phenomenological method is also an exclusion rule. What should be excluded is the non-essential. Only what is essential to an object should be included. Thus, not all parts and what is non-essential should be excluded. Existence should be excluded, because the inquirer does not proceed from what does exist. It is sufficient that the object be given as a phenomenon. For example, to ground a theory of liberal education, the essence of liberal education must be set forth and such setting forth is possible even though liberal education be non-existent and merely imagined. What is contingent should be excluded. Inference is the ground of all deduction and retrodiction. The known not directly given is to be found in the literature. What is asserted by others must never be relied upon as a foundation. Knowledge must be the product of the human mind, as stated above.

The final two rules, the fifth and the sixth are positive ones. The fifth rule is to see everything that is given. There is a tendency to see only what one takes as important and to be ignored is indirect knowledge. The described metaphysics is from science and praxiology. The descriptive metaphysics is from science and praxiology. It ignores existence, while the scientific or praxiological inquiry treats contingent relations and essences within existence.

The final two rules, the fifth and the sixth are positive ones. The fifth rule is to see everything that is given. There is a tendency to see only what one takes as important and to be ignored is indirect knowledge. The sixth rule is to be descriptive. The due to which they must be to an inner kind of thing and the elements described. Heidegger, another German phenomenologist, calls this kind of analysis ’exesis’ or ’hermeneutics’.

In summary the phenomenological method consists of six rules.

Rule 1: Focus on the object
Rule 2: Exclude the subjective
Rule 3: Exclude indirect knowledge
Rule 4: Exclude existence and the contingent
Rule 5: Strive for complete disclosure
Rule 6: Be analytic

Rule 1: Focus on the object. Rule 1 insures that intuition can take place as do Rules 2, 3, and 4. Rule 1 results in contemplating the object. Rules 2 and 3 result in a threefold eidetic reduction—indirect knowledge through deduction or retrodiction, and tradition are excluded. Rule 4 through a twofold reduction excludes all that is not essential—existence and the contingent. At this point in the method there has been a reduction to the life of consciousness so that significance is possible. Through Rules 5 and 6 meaning is forthcoming; description is accomplished.

It should be pointed out that the process within the twofold reduction is like the method of counter-examples; it is the method of free imaginative variation. In this method, one inquires as to the essentiality of each characteristic of an example. But one can also approach empirical observation nor does one simply regard a characteristic as essential. Instead with the method of counter-examples, whether or not an example could be considered an example of the same sort of thing as before. One asks what characteristics an example has in mind and whether, for example, one can be considered an example of a certain kind of object. To illustrate, in my phenomenological inquiry into education, I asked whether a process could be education without having an active learner and a teacher. Thus, I determined that a process must be a teaching-learning one in order to be education.

The other form of reasoning through which the process can be devised is reductio. Peirce pointed out and named this form of reasoning.

The inquiry begins with pondering these phenomena in all the circumstances of view wherein the wonder shall be resolved. At length a conjecture arises that furnishes a possible explanation, but one which also undergoing the surprising fact as necessarily consequent upon the circumstances of its occurrence together with the truth of the conjectured hypothesis. . . . The whole series of mental performances between the notice of the wonderful phenomenon and the acceptance of the hypothesis as composing the First Stage of Inquiry. Its characteristic formula of reasoning 1 term Retroduction. (VALUES IN A UNIVERSE OF CHANCE, p. 267)

Following Peirce (COLLECTED PAPERS, 5,189), the form of the retrodictive inference can be set forth.

1. The surprising phenomenon, C, is observed; and
2. but if A were true, C would be matter of course;
3. hence, there is reason to suspect that A is true.
From the above form, it is patent that retroductive inferences support lines of thought as worthy of exploration and testing; they do not establish the truth of thought. Retroduction originates ideas.

Through retroduction one devises concepts and propositions. To explicate retroduction further, I devised the theory model as an approach. The scientific papers of the outstanding nineteenth-century theoretician James Clerk Maxwell were a help because in them he elucidated what was involved in using the point of view to devise theory. In his essays, "On Faraday's Lines of Force," he spoke of the relation between the point of view and the theory in terms of physical analogies.

In order to obtain physical ideas without adopting a physical theory we must make ourselves familiar with the existence of physical analogies. By a physical analogy I mean that partial similarity between the laws of one science and those of another which makes each of them illustrate the other. (p. 156)

Then he cited an example:

The laws of the conduction of heat in uniform media appear at first sight among the most different in their physical relations from those relating to attractions. The quantities which enter into them are temperature, flow of heat, conductivity. The word "force" is foreign to this subject. Yet we find that the mathematical laws of the uniform motion of heat in homogeneous media are identical in form with those of attractions varying inversely as the square of the distance. We have only to substitute source of heat for centre of attraction, flow of heat for accelerating effect of attraction at any point, and temperature for potential, and the solution of a problem in attractions is transformed into that of a problem in heat.

This analogy between the formula of heat and attraction was, I believe first pointed out by Professor William Thompson in the Camb. Math. Journal, Vol. III. (p. 157)

Finally, he set forth the point of view which he used to devise his theory of electricity.

It is by use of analogies of this kind that I have attempted to bring before the mind in a convenient and manageable form, those mathematical ideas which are necessary to the study of the phenomena of electricity. The methods are generally those suggested by the processes of reasoning found in the researches of Faraday . . . ( Ibid.)

By referring everything to the purely geometrical idea of the motion of an imaginary fluid, I hope to attain generality and precision. . . . If the results of mere speculation which I have collected are found to be of use to experimental philosophers, in arranging and interpreting their results, they will have served their purpose . . . (p. 159)

Surely the passage of time since Maxwell's day has indicated that the generality and precision (theory) achieved through the idea of the motion of an imaginary fluid (point of view) did achieve arrangement and interpretation (integration) of electrical phenomena as observed by experimental physicists. The purpose was served.

Maxwell's discussion clarified how theory models function in devising theory. The theory of mechanics furnished content (concepts) and form (ways of relating concepts) which were represented in another system of propositions. So the theory of electricity emerged. The theory of mechanics was a source of a model for devising the theory of electricity.

In general then, since retroductive inference is based upon similarity, it is a theoretical modelling: one theory because of its similarity to what another theory needs to be is used to devise the theory. The theory models approach is set forth in Schema 28.

model formation theory formation

THEORY

Schema 28: Theory Models Approach

The theory models approach is retroductive and so is neither reductive nor deductive. To be reductive would mean that the wanted theory that is devised is equivalent to the source theory for in this approach one would search out a ready-made theory. It is obvious that not all ideas are already made and waiting. Ideas must be devised. To be

deductive would mean that the wanted theory is derivable from a source theory that is more general and thus implies the wanted theory. Also it is patent that not all basic or general ideas are already given. To be retroductive in approach one must originate ideas.

Schema 29 presents a comparison of these three approaches. Since in the reductive approach the source theory, $T_1$, and the wanted theory, $T_2$, are equivalent, $T_1$ and $T_2$ are represented by circles of the same size. In the deductive approach, $T_1$ is more general than $T_2$, which means that the source theory contains not only the wanted theory but yet other theory. Hence, $T_1$ is represented through a larger circle which contains $T_2$. Containment should be taken in the sense of $T_1$ implying $T_2$. Finally, in the retroductive approach, the source theory does not contain the wanted theory (what one ends up with cannot be implied by what one already has). The source theory is depicted by a circle representing $T_1$ within a square representing $T_2$, so as to indicate that the source theory and the wanted theory are different. The source theory is different. This comparison shows the relationship between the different discourses, no relation of implication is possible even from $T_1$ to $T_2$, yet the theory source is placed within the wanted theory, so $T_1$ generates $T_2$.

Referring back to the discussion of models in "1. RECOGNIZING THEORY", it should be noted that theory models are conceptual models and also models-for. Also it was pointed out that one reason for calling a theory 'a model' is the notion of distance, from one model to another, a theory model formed from $T_1$ which results in seeing the model in the theory $T_2$ for example, the theory of DNA (deoxyribonucleic acid) is called the model of DNA, because the theory model of the helix, which has its source in geometric theory, is seen in the theory.

An example of the use of the theory models approach is found in DEVELOPMENT OF EDUCATIONAL THEORY DERIVED FROM THREE EDUCATIONAL THEORY MODELS, 1964.

First, a theory model was formed. The theory model was called "SIGCS" because it was a general system theory (GS) formed from set theory (S), information theory (I), and graph theory (G). Set theory was basic to the model, since it is used to form general system theory both directly and indirectly through information theory and graph theory. The interaction of set, information, and graph theories as they form general system theory is depicted in Schema 30.


deductive

Retroductive (Theory Models) Approach

Schema 29: Comparison of Approaches to Theorizing

$T_1$ is the theory from which $T_2$, the wanted theory, is to be obtained.
System theory is basic to all descriptions, as was pointed out in the discussion of explicating descriptive theory. Since theory treats of extended objects—objects that are not individually but are class objects—and a system is any extended object, theory about any system gives form to descriptive theory.

The intuition that the essence of reality is system surely dates back to the ancient Greeks who bequeathed to us the rational mode of inquiry which is a systems approach. The basic form of all theory is system theory. Thus, this basic formal theory is known as "general systems theory." As is common in the literature, the plural of "system" is used. It would make more sense not to because "General" has the same meaning as the "s" (Ashby, p. 3).

The Sigos Theory Model, thus, is a general system theory which is a formal theory model for all descriptive theory. As such the Sigos Theory Model falls in the category of syntactic rather than semantic theory models.

The Sigos Theory Model extends von Bertalanffy's formal definition of system complex of elements standing in interaction (General Systems Theory, p. 33) to a system is a group of at least two components which at least one affect relation and with information.

System becomes a set of points and an affect relation a set of directed lines. Not only is set used, but also the set theoretic definition of 'function.' An affect relation is a mapping of the group into itself. Through information theory, information of a system becomes a characterization of system occurrences at categories in a classification. System occurrences may or may be with respect to either system components or system affect relations or both. Since a classification is a set of categories, set theory also is basic to information theory.

Properties of a system allow specification of kinds of systems, since properties are conditions on the system which either specify its structure or its state. Explicit use of set theory is exemplified in the properties of size and sameness. In the former, the set theoretic characterization, cardinality, is explicit, while in the latter, homomorphic or isomorphic or automorphic mapping is.

The set characterization, complement, marks off the system from its surroundings, the negasystem. Within whatever universe of discourse selected, the components selected for consideration, the components which do not belong to the system are the negasystem. See Schema 31 on the next page.

Information theory gives meaning to the categorization of the components and connections of a system and its negasystem. Every system has information in the sense that occurrences of its components or affect relations or both can be classified according to categories. The added condition of selectivity of the information, i.e., uncertainty of occurrences at the categories, is required to develop information properties of systems and negasystems and of their states. Schema 31 summarizes and illustrates the basic information properties of a system (top input, storeput, feedin, feedout, feedthrough, and feedback) and of a negasystem (fronput and output).

Only the condition of selectivity is required to give meaning to top input, output, and output. Both input and output involve selective information on a negasystem, whereas fronput and input involve selective information on a system. Nevertheless, topinput can be added from output, and fromput from input. Top input is a system property, a system's environment or the selective information on a negasystem available to a system, but output is a negasystem property, its selective information. Fronput is a negasystem property, a negasystem's environment or the selective information.
available to a negsystem, but input is a system's property, its selective information.

The other basic information properties require conditions that are more complex than merely being available to a negsystem but input is a system's property, its selective information.

The complete SIGGS Theory Model is presented in Appendix III. It consists of a group of related terms. The terms are related so that some are primitive, undefined, and the others are defined. As discussed in 3. EXPLICITING THEORY, primitive terms are required to prevent circularity. Moreover, all the defined terms are defined through primitive terms or defined terms which already were defined by means of primitive terms. Since the terms are characterized with respect to a system in general and not with respect to only one kind of system, e.g., an education system, the theory model can be said to be a group of related formal characterizations of a general system.

Because set theory, information theory, and graph theory were utilized, the power of these formal theories made precision and extension of a general system theory possible. Logico-mathematical ideographs are powerful theoretical tools. It should be noted too that the SIGGS Theory Model also incorporates truth functional and quantification systematics which are set forth in Appendix I.

In devising education theory from SIGGS, teacher, student, content, and context are taken as forming a system of education. In set theoretic notation:

\[ E = \{ t, s, c, x \} \]

where 't' stands for system of education
's' stands for teacher
'c' stands for content
'x' stands for context

In a set, the elements form a unit within a universe of discourse. In the devised education theory, this means that a system of education can be considered within various spheres: home, church, state, etc., but it cannot be considered within any sphere. The unit must be consistent with the universe of discourse. It does not make sense to consider a system of education within a molecule, but it does make sense to consider an atom within a molecule.

Given a set within a universe of discourse, the universe which is not the set is its complement. This set theoretic notion of complement gives precision to a system's surroundings or to what is not system. What is not system is called 'negsystem'. When the system of education is considered within a state, the negsystem consists of persons, culture, and objects within the state but not within the system of education.

Schema 32 summarizes the use of the set theoretic notions in delineating a system of education and its negsystem.

It should be noted that what is taken as a component is one universe of discourse can be taken as a system in another. The components of the system, education, are called 'subsystems', for either the student, teacher, content, or context can be taken as a system. Changing the universe of discourse over and above that of selectivity, the student can be taken as a system rather than as a component. One would then change not only one but also the teacher, content, and context. The components would be the components of the system and the component's name only go from the teacher, content, and context—would be those of the negsystem.

Within education one is not limited to the components as systems. A combination of components could be taken as system. The negsystem would change accordingly. The figure in schema 33 on the next page show within education three different system perspectives.

Set theory not only gives precision to 'complex of elements' but also to 'standing in interaction'. The precision is obtained by utilizing the set theoretic definition of function. Since a function of one set into another is constituted by an association of elements in one set with those in the other, standing in interaction can be interpreted as a mapping of the set into itself, and hence as affect relations. Analogously, the affect relations between the components of an education system are constituted by the mapping of teacher, student, content, and context into teacher, student, content, and context. That is to say,

![Diagram of Education as a System](image-url)

![Diagram of Teacher as System](image-url)

![Diagram of Student as System](image-url)

Schema 33: System Perspectives Within Education
where there is association between a teacher property and a student property, the teacher property affects the student property of the student property is a function of the teacher property.

Set theory is also utilized to give precision to conditions on the system of education over and above the essential ones treated above. It is used explicitly to give precision to conditions on the system characteristic such as sameness within an education structure. For example, uniformity in the content of education is viewed by means of isomorphic mapping. Set theory is used implicitly when information or graph theories are utilized for characterizing education. This is so, because set theory is basic to both information theory and graph theory.

Digraph theory is mathematical theory which characterizes, between pairs of points, lines which can be directed. Figures can be utilized to explicate intuitively a digraph, as in Figure 1.

![Figure 1](image1)

Figure 1 was constructed from points - $s_1$, $s_2$, $s_3$, $s_4$, $s_5$ - and lines, some of which are arrows. There is an arrow between the points $s_1$ and $s_2$ and $s_2$ and $s_3$. There are no lines between $s_3$ and the other points. Thus, $s_3$ is not connected to or paired with any of the other points. Where there is an arrow between two points, there is a directed connection or a pairing. Consequently, there is a directed connection or a pairing between $s_1$ and $s_2$, $s_2$ and $s_3$, $s_3$ and $s_4$, and $s_4$ and $s_5$. Given only one arrow between two points, the directed connection is direct as in $s_1$ and $s_2$, $s_3$ and $s_4$ and $s_4$, and $s_2$ and $s_3$. Where there is a line without an arrow, a directed connection will be assumed in one or the other direction or in both directions. (The result of such an assumption is the treatment of graph theory within the context of digraph theory.) Dotted lines indicate the possibility of one of the two entries being 0.

Figure 2

![Figure 2](image2)

Utilizing graph theoretic properties in theorizing about education, transmission of culture in a group consisting of a teacher and five students will be considered. Let the point $s_1$ represent the teacher, $s_2$, $s_3$, $s_4$, and $s_5$ the students, and lines between the points transmission channels. Figure 1, therefore represents a system in which there is no connection between the teacher and any of the students. The teacher does not transmit culture. On the other hand, Figure 2 represents a system in which there is a connection between the teacher and each of the students. The teacher does transmit culture. However, each student is in the same position as the teacher in regard to the transmission of culture.

In order to treat transmission, information theory must be used as well as graph theory. Information is the characterization of occurrences. This fits in with the ordinary notions of information. When one is informed, one knows what can characterize what is happening. To characterize occurrences is to classify them according to categories. But, for describing transmission, the condition of selectivity must be placed upon information. There must be uncertainty of occurrences at the categories. Uncertainty of occurrences is explicated in terms of a probability distribution. In a system context, if there is uncertainty with respect to an occurrence of a system component at a category of classification of the system components, then the probability at the category can be neither 1 or 0 but must be less than 1 or greater than 0. Consequently, there must be at least one alternative category for the occurrence of the components, since the sum of the probabilities must be equal to 1. Alternatives indicate selection. This selective sense of information also fits in with the ordinary notion of in-

formation. One needs information only when one does not know something. One must be certain or faced with a choice between alternatives. Complete knowledge involves no uncertainty or information.

The basic information function is designated by $H$. By summing over the amount of information associated with each decision, weighted by the probability that the selection will occur, the value of $H$ can be obtained. To state the matter more precisely, $H(C)$ is the average uncertainty per occurrence with reference to the classification of $C$; it is the average number of decisions needed to associate any one occurrence with some category $c_i$ in $C$, with the provision that the decisions are appropriate; it is a function of the probability measures in $C$:

$$H(C) = \sum_{i=1}^{n} p(c_i) \log_2 \frac{1}{p(c_i)}$$

The measure for joint uncertainty would be

$$H(C_{ij}) = \sum_{i=1}^{m} \sum_{j=1}^{n} p(c_{i,j}) \log_2 \frac{1}{p(c_{i,j})}$$

The measure for conditional uncertainty would be

$$H(C_{ij} | C_j) = \sum_{i=1}^{m} \sum_{j=1}^{n} p(c_{i,j} | c_j) \log_2 \frac{1}{p(c_{i,j} | c_j)}$$

The three $H$ measures are related as follows:

$$H(C_{ij}) = H(C_{ij} | C_j) + H(C_j)$$

The T measure is the amount of shared information:

$$T(C_{ij}, C_j) = H(C_{ij}) - H(C_j)$$

The information theoretic notions of SIGSS provide a framework for categorizing the four major teaching-student components. These components can be set forth within the set theoretic framework as described above. To illustrate, the verbal behavior of teachers can be treated as selective information, and hence the probable occurrence
of instances in categories is determinable. Categories of teacher verbal behavior need to be worked out along lines such as the kind of initiating behavior consisting of either structuring or soliciting and reflexing behavior consisting of either responding or reacting. (The Language of the Classroom, 1965) Determination is through obtaining a measure or the amount of uncertain factors for given verbal behavior in any one of the categories. One could, of course, also likewise for student verbal behaviors. Thus all elements of the education system or subsystems conceivable could be categorized thusly. Therefore, SIGGS information is complex, as are topics and input, can be used in developing education theory.

Information theoretic notions also help to characterize interactive aspects of education. One can determine the flow of verbal behavior from student to teacher through the conceptual scheme which is the foundation for measuring the amount of student verbal behavior--the topic--and on teacher verbal behavior--input, then the commonality can be measured. The obtaining of the equation can inform one of the interactive verbal pattern between student and teacher. Is the student getting through to the teacher? Is the teacher's verbal behavior as reflexive as the student's is initiating? Etc.

Other examples of the use of the theory models approach in constructing theory can be found particularly in the literature on the dialectical approach in sociology and in education. The Hegelian theory is used as an example as sources for the development of theory of society and theory of education.

Fichte (1762-1814), not Hegel, introduced the triad of thesis, antithesis, and synthesis (Grundlagen der gottlichen WissensClasse) but the analogy to the triad of thesis, antithesis, and synthesis did not go beyond the thesis and antithesis. Fichte, a descendant of the Platonic tradition, had thought pass over into their opposites and then achieve a higher truth. He added determinate conclusions in thought necessarily lead to a further phase of development. One of the most important derivations from the Hegelian dialectic was the Marxian. In this dialectic, matter was substituted for mind. The dialectic was combined with materialism and constituted dialectical materialism (a phrase devised by G. Plekhanov and first used in a publication in 1891). Marx (1818-1883) applied dialectic to history and so

Marxist conception of a social structure divided between those who control power and wealth--establishment forces, and those who are subordinate, manipulated, and exploited--anti-establishment forces, do however yield the dialectics marked by inevitable conflict. The critical theory of the Frankfurt School (Adorno, Horkheimer, Marcuse, Fromm, et al) and the Neumann's are among its members, is the most explicit neo-Marxist example of dialectical sociology.

Finally, the neo-dialectical framework of Llewellyn Gross (1914- ) should be mentioned. It is a method for building dialectical sociological theories. Gross's general methodology is an encounter of challenges and confrontations, theses and countertheses. The widest possible variety of theories, including functionalist and conflict theory, can be included to provide a basis for derivation of a new and more meaningful synthesis. Gross calls this approach to theory building "an open system approach.

G. B. McCall (1979) has written of Harris's and Dewey's use of the dialectic to develop education theory. During the nineteenth century, W. T. Harris utilized the Hegelian sense of dialectic to view education as self-development mediated through interaction. This self-development was taken to be one in which thoughts pass over into their opposites and then achieve a higher truth. During the nineteenth century, Dewey utilized the dialectic from a dialectical context and thus conceived education as a transaction in which experience develops toward that which is fundamental" (p. 2)

Contemporary psychologists of education, however, do not use the dialectic in their theory. Their theories of how cognitive development is central in their theory, developing, and not viewed through resolution of contradictions in thought.

Sociologists, on the other hand, have utilized dialectic in their theorizing about education. Some sociologists see education within a dialectic conflict theory. This way of looking at education which recognizes the way of looking at education through the functional paradigm.

In simplest terms, the functional paradigm argues that schools are essential institutions in modern society because they perform two crucial functions:

historical materialism (a phrase used by Engels) emerged. History was seen as a series of stages, each based on forces of production and characterized by certain relations of production. Four stages were distinguished: primitive communism, ancient based upon slave labor, feudal based upon serfdom, and capitalist based upon wage labor. In these stages, stages are characterized by the means of production, and thereby alienated from society and themselves. The dialectical process will come to an end in the class society in which there will be no division into exploited and exploitors.

Dialectics in sociology involves a use of opposing tendencies or contrasting propositions.

Georges Gurvitch (1896-1965) criticized Hegel and Marx for only recognizing one form of dialectics, polarization. He also recognized complementarity, mutual involvement, ambivalence, and ambiguity of and between categories. Hence, there are five ways in which opposing social elements can be conceived to maintain a sense of unity: to attract, repel, and manifest in inverse ways, as well as to take up conflicting positions. Gurvitch's view is similar to that of an empirical dialectics", since he grounded his dialectical treatment of social reality in empirical reality.

Luigi Sturzo (1871-1959) presented a theory of 'the concrete society' in a dialectical form with opposing elements of personality and collective value, not opposed between the individual and society but also within the individual. Social harmonism is a synthesis of personality and collectivism.

Walf Dahrendorf (1929- ) developed a dialectic conflict theory of society. The conflict of all social organizations into two opposing roles, those with authority and those subordinate to authority, gave rise to the conflict of society. The theory of society is one of concensus and equilibrium and emphasizes shared values and social integration. Moreover, conflict is taken as a deviation from the mechanisms of social control. However, conflict is as structural as social life is as consensus. Thus, the dialectic conflict theory of society is required along with the functionalist theory of society.

The critical and radical sociology of C. Wright Mills (1916-1962) and Alvin W. Gouldner incorporates the sociological analysis of a world in which schools and society are often poorly understood and neglected. This world of education is one of inequality and injustice. Schools are instruments of elite domination, agencies that foster compliance and docility rather than independent thought and human value. (Mura, p. 31)

Many of the contributions to the conflict portrayal of education is the example of Bowles and Gintis' theorizing about education.

... the educational system's task of integrating young people into adult work roles constrains the types of personal development which it can foster in ways that deviate from the fulfillment of its personal development function. (p. 124)

... the education system plays a central role in preparing individuals for the world of alienated and stratified work relationships. Such a class analysis of the system's role is necessary to understand the dynamics of educational change ... (p. 124)

Although the contrast between the functional and conflict paradigms and significance such as Bowles' idea one to the neglect of the impact of change and conflict, such neglect is not inherent in functionalism. The functional paradigm is suited equally to explain conflicts and change and to explain order and stability. (Bromley states the matter well:

One may analytically construct a static systemic functional model by combining general assumptions of
functionalism with the following set of particular assumptions: functional reciprocity, consensus, dependence, universal functionality, uniform functionality, equilibrium, commensurate functional requirements, constant functional requirements, functional unity, and subsystemic integration. As one may as well construct a dynamic systematic functional model by combining the general assumptions with the opposite set of particular assumptions: exploitation, conflict, autonomy, dysfunction (or specific functionality), differential functionality, disequilibrium, contradictory functional requirements, changing functional requirements, functional duality, and subsystemic disintegration. (pp. 143-146)

An example of a functional paradigm equally suited to analyse any system is the integrative and dynamic aspects is the SIGGS Theory Model explicated above.

Maccio and I have used SIEGGS to theorize about education as a social system (1966, 1971, 1973, 1975). In the 1975 work, the teacher subsystem and the learner subsystem within the education system were conceived not only in terms of maintenance but also in terms of change (constructing or destructing). In an effective education system, both the teacher and the learner subsystems must be constructing. Neither one nor the other can be either maintaining or destructing. There can be no contradiction, no constructing and no destructing. This lack of a mechanistic or static state of mutuality, a transactional relation in which experience is reconstructed and grows.

In addition to the use of the dialectic in the sociology of education, it can be used in philosophy of education. I used it to generate a theory of liberal education, i.e., ecology of the free.

Through social liberalism, the concept of liberal education evolves from cultivation of the intellectuals of Free men for their enjoyment and cultivation of the words of slaves for their transformation of the world through revolution.

Thus, in such an object the parts have natures which are non-modifiable. These parts, consequently, have fixed actions. The actions which are specific to a certain kind of machine result from a combination of parts. The effects are linear and additive. Therefore in an organic state of affairs the parts are non-modifiable and the determining factors.

An organismic point of view is one in which phenomena are represented like an organism. An organism is a structured whole, one in which the function and form of its parts are determined by its function. Thus, in such an object the parts do not have non-alterable natures and so fixed actions. Rather parts act interdependently to maintain function, and thereby wholeness. The parts do not simply combine and determine what the whole is to be. Effects are not linear and additive. The content and form of the parts change relative to a whole. Therefore, in an organismic state of affairs the parts are modifiable relative to the emergent whole.

In LOGICAL AND CONCEPTUAL ANALYTIC TECHNIQUES, I recognized in educational theorizing the mechanistic point of view and called the machine model employed, "the educational effects model". Schema 34 represents such a model.

![Schema 34: Educational Effects Model](image)

This model is the governing one in psychological theorizing about education.

In the organismic point of view, I called the organism model employed, "the educative configurations model". The functional approach in the sociology of education is such a model as is SIEGGS.

The SIGGS theory model permits representation of organized complexity. Set theory enables quantification of a complex organization as a graph structure; and Information theory extends the cybernetic education theory model (an educative configurations model shown in Schema 35) so that education-surroundings interactions can be described.

to cultivation of the social intelligence of human beings for their freedom.

Thus, from the thesis, ecodology of the oppressor, and the antithesis, ecodology of the oppressed, emerges the synthesis, ecodology of the free. (1981, p. 29)

Pepper in WORLD HYPOTHESES has argued that there are four basic theory models in terms of which one views the world. One can view the world as constituted of unalterable parts (forms), and thus embrace formism. Or one can view the world as a consisting of fixed actions, the world acts in predetermined ways due to its unalterable parts. Since a machine acts in such a fashion, one who takes this view embraces mechanism. It should be noted that formism and mechanism are essentially the same position; formism is the static state of affairs whereas mechanism is the dynamic state is emphasized. The other two possibilities for viewing the world are organismism and contextualism. Under organismism, the world is seen as constituted by parts that are not unalterable. The parts change through time. Since the parts of organisms are like that, growth occurs, the analysis of the view is act. Contextualism is the dynamic counterpart to organismism; the parts do not have fixed actions rather their actions are determined by the whole they are in, by their context.

Since, from the standpoint of a complete description of a system and its structure and its state, formism and mechanism form a pair and organismism and contextualism form another pair, I take two analogies to be the overarching ones for the analysis of the machine and the analogy of the organism. Black has called overarching theory models, "archetypes", and Ruhn has called them "paradigms".

To be more explicit, a mechanistic point of view is one in which phenomena are represented like a machine. A machine is an object that consists of parts that act in predetermined ways to bring about certain specific effects.

![Schema 35: Cybernetic Education Theory Model](image)

In SIEGGS as presented in Schema 31, input and a new sense of output are added to input and output which is newly interpreted as spurnput. Determination is now possible not only of what education takes in and what is available from it, but acts on what education's surroundings take in and what is available to them. Feedin, feedthrough, and feedout are added to feedback which is not interpreted as flow from input. Thus, to both the system and its surroundings can be characterized.

To illustrate, the flow of culture from teacher to student can be represented through the concept of Feedin, which is shared information. For this representation, culture must be interpreted as selective information, i.e., as probable occurrences in categories of societal expressions. Taking an H measure on the culture of the teacher that is available to the student (input relative to the student subsystem) and an H measure on the culture taken in by the student (input of the student subsystem), the T measure of commonality between topics as input can be obtained. Commonality indicates a flow in culture or decreased uncertainty which is what learning is.

The final form of reasoning to consider is deduction. Although deduction does not enter into the devising of theory, it is required to explicate theory. As Peirce stated it:

... neither Deduction nor Induction contributes the smallest positive item to the final conclusion of the inquiry rendered by the premises. Deduction explicates: Induction evaluates; that is all. (COLLECTED PAPERS, 5.145)

It should be noted that I sorted out the explication of theory from the construction of theory. However, explication has a different function from that which I have just made, explication has the sense of setting forth the content
and form of an already developed theory. In Peirce's sense, explicative means extending and extending the content and form of a theory that one is developing.

The form of deductive inference is as follows:

1. If A were true, then B would be true.
2. A is true.
3. Hence, B is true.

The methods for such inference are found in truth functional and quantification syntactics. (See APPENDIX I.)

Deductive methods now will be considered as they enter into extending and extending theory.

As seen in 3. EXPLICATING THEORY, classification is basic to descriptive theory. Descriptive metaphysics is a division of reality that the metaphysician--the system--so that a set of descriptors characterizing the system's properties emerges. To do this, the metaphysician must provide a set of class terms for characterizing each and every component of the system.

In providing a set of class terms, the metaphysician utilizes the methods of deductive logic. Bifurcation is the method related to partitioning or dividing. Bifurcation is based on the principle of identity. Either a phenomenon has a certain characteristic or it does not. Thus, the phenomena are placed in two groups according to the presence or absence of a given characteristic. Given a characteristic, therefore, the number of classes would be 2^n.

An example of using bifurcation is my emendation of Dewey's theory of education in which he took education to be as broad as all learning. I partitioned learning into two characteristics: intended and guided. 2^4 or 16 classes were developed. These classes of learning: intended and guided, intended and non-guided, non-intended and guided, and non-intended and non-guided--are represented in Schema 8.

Another example of the use of the method of bifurcation is Walkin's classification of multicritical education curriculum phenomena according to three characteristics: effective (the use of criteria to judge material about cultures to be included) and not selective (called by Walkin "tolerant"), absolutist (belief in general structures or principles of knowledge) and not absolutist (called by Walkin "relativist"), and transformationist (aiming at changing culturally and not transformationist (called by Walkin "transmissionist"). ("The Idea of a Multicultural Curriculum") Since there are three characteristics, there are 3 classes of 4 classes (8 classes or 3 classes of 8 classes).

Moreover, Walkin's classification can be utilized as an example in theory construction of applying another principle of deductive logic, the principle of contradiction. The fact that no valid scheme is represented in Schema 8, classes that do not correspond to this principle should be ruled out. In Walkin's classification, the classes having the characteristics of both selective and relativist are logical impossibilities, because selection implies no relativism: if one uses criteria to judge material about culture than one does not believe that there are any general structures of knowledge. Also I utilized the principle of contradiction when I ruled out classes of theory in Schema 8.

Schema 8 illustrates another method used in classification, the union of classes. Knowledge was sorted according to content and form into logical, mathematical, philosophical descriptive, philosophical explanatory, psychological, and scientific classes; and knowledge was sorted according to object into physical, biological, and homological classes. These two classifications were combined through crossover (6 classes x 3 classes) to produce 18 classes. Of those 18 classes, 6 classes were ruled out as impossibilities. Formal knowledge--logic and mathematics--implies knowledge that has no object. Thus, physical logic and psychological logic are logical impossibilities.

Yet another method used in classification is class inclusion. Class inclusion is basic to classifications which are taxonomies. On pages 67 and 68, I set forth the logical requirements for a taxonomy. A taxonomy which I developed through the use of class inclusion is represented in Schema 18. Education was partitioned into teacher, student, content, and context. Then content was partitioned into cognitive, affective, and effective structures. Cognitive structures were partitioned into quantitative, qualitative, and performative ones. Quantitative structures were partitioned into individualistic, theoretical, and individual structures. The deduction is as follows:

1. p ∨ q
2. r ∨ p
3. r ∨ q s
(1) (2) T
4. p · q · r ∨ p s · r ∨ q s

where 'p' stands for human psyche
'q' stands for cognitive, affective, and effective structures
'r' stands for human learning
's' stands for development

Axiomization is another method that is important in constructing explanatory theory. The descriptive theoretical sentences expressing relations between characteristics are systematized. The theoretical sentences are connected deductively. A system in which for each possible interpretation of the calculus that makes the axioms (postulates) true, every theorem is likewise true (the principle of completeness) is called a calculi.

EXPLICATING THEORY, there is a discussion of the method of axiomization with an example.

At least one caveat is in order with respect to the method of axiomization in social theory and so in education theory. A full formalization of the system, since one must presuppose large segments of disciplines other than those indigenous to the theory being constructed. Psychology presupposes both psychology and sociology; and philosophical theory is presupposed by all. Hence one should not formalize as much as one can. The material that is nonindigenous to the theory should not be part of the formalization. Rather one should make clear what theories are presupposed.

In summary, theory should be envisioned through the above
methods so that:

1. the form of descriptive theory is altered to meet the criteria of equivalence, chaining, and substitution;

2. the content of descriptive theory is altered to meet the criteria of exactness, exhaustiveness, external coherence, and extendability;

3. the form of explanatory theory is altered to meet the criteria of determinacy and internal coherence;

4. the content of explanatory theory is altered to meet the criteria of well-defined terms, correspondence, comprehensiveness, and external coherence.

The criteria mentioned above are explicated in 4. EVALUATING THEORY.

In extending theory, theory often is extended. For instance, making a theory more complete is adding to theory. Gaps in a theory are filled in or the theory is made more comprehensive. The methods related to the form of reasoning that feature in constructing theory are used to extend theory.

The gaps in a theory can be filled through phenomenological analysis or through the theory models approach. However, there may be extant theory to fill the gaps. The related theory to be gap-filling must be deducible from the theory being extended; the method of derivation features here.

Theory can be made more comprehensive, broadened, through phenomenological analysis or through the theory models approach. However, again there may be extant theory to do the broadening. The theory used to broaden theory must either be more general than the theory or must be of the same order of generality. Homologious literature (as examples: psychology, sociology, epistemology, ethics, social philosophy, human praxiology (engineering), and social praxiology (engineering) rather than literature about physical phenomena (as examples: physics, natural philosophy, and civil praxiology (engineering)) is a more probable source for general theory to broaden education theory. This is so, because generalizations about the teaching-

studying process must be deducible from the source theory.

When one is selecting extant theory to fill gaps or to broaden theory, one needs to compare theories as to their worth relative to that effort. In 4. EVALUATING THEORY, criteria for evaluating theories against other theories were presented.

The conclusion of this section on constructing theory does not present ordered steps. The reason should be obvious. Theory amending and extending are not mechanical matters. Hopefully, in this text I have presented some insight into the construction of theory.

APPENDIX I

1. Truth Functional Syntax

1.1. Truth functional operations are negation, conjunction, alternation, and biconditionality. These operations are ways of transforming sentences expressing propositions into other sentences expressing propositions so that the truth value of the generated sentence depends upon the truth value of the sentences from which they are generated.

1.2. Negation is a truth functional operation by which a sentence is transformed by attaching 'not' to the verb of a simple sentence or 'it is not the case' to a compound or complex sentence. For example, to negate the sentence,

1.2.1. leniency in grading does increase learner motivation

'not' is attached to the verb 'does increase' as follows:

1.2.2. leniency in grading does not increase learner motivation

and to negate the sentence,

1.2.3. leniency in grading increases learner motivation and achievement

'it is not the case' is attached to the sentence as follows:

1.2.4. it is not the case that leniency in grading increases learner motivation and achievement.

These linguistic formations can be symbolized as follows:

\[
\begin{array}{c|c|c|c|c|c}

\text{p} & \text{q} & \neg \text{p} & \neg \text{q} & \text{p} \land \text{q} & \text{p} \land \neg \text{q} \\
\hline
T & T & F & F & T & F \\
T & F & F & T & F & T \\
F & T & T & F & F & T \\
F & F & T & T & F & F \\
\end{array}
\]

To translate

if it is true that leniency in grading does increase learner motivation and then it is not true, then it becomes false that leniency in grading does increase learner motivation

if it is false that leniency in grading does increase learner motivation and then it is not false, then it becomes true that leniency in grading does increase learner motivation

if it is true that leniency in grading increases learner motivation and achievement and then it is not true, then it becomes false that leniency in grading increases learner motivation and achievement

if it is false that leniency in grading increases learner motivation and achievement and then it is not false, then it becomes true that leniency in grading increases learner motivation and achievement

1.3. Conjunction is the truth functional operation by which two or more sentences are transformed through linking them by 'and', 'but', 'although', and 'while' are taken as
equivalent to 'and', although in ordinary language these terms compare as well as link. To illustrate conjunction, to conjoin

1.3.1. teaching is interactive

1.3.2. teaching is intentional

1.3.3. teaching is correctional

they are linked by 'and' as follows:

1.3.4. teaching is interactive and teaching is intentional and teaching is correctional

A shortened version of 1.3.4. is

1.3.5. teaching is interactive and intentional and correctional

Symbolization is as follows:

1.3.1. p
1.3.2. q
1.3.3. r
1.3.4. pqr
1.3.5. pqr

where 'p' stands for teaching is interactive
'q' stands for teaching is intentional
'r' stands for teaching is correctional

Following Quine, no symbol is used for 'and', although 'a' is often so used.

The above conjunction as well as all conjunctions are associative: internal grouping is immaterial; e.g., 'teaching is interactive and teaching is intentional and correctional' is equivalent to 'teaching is interactive and intentional and teaching is correctional', i.e., 'pqr' is equivalent to '(pq)r'

commutative: order is immaterial, i.e., 'pqr' is equivalent to 'rqp'

idempotent: repetition does not add content, i.e., 'pqr' is equivalent to 'pqr'

The truth values after conjunction are indicated in the following table:

<table>
<thead>
<tr>
<th>p</th>
<th>q</th>
<th>r</th>
<th>pqr</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>T</td>
<td>F</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
<td>T</td>
<td>F</td>
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<td>F</td>
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<td>F</td>
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</tr>
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<td>F</td>
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<td>T</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>

Clearly if and only if all conjuncts are true before they are conjoined will the conjunction come out true. In all other cases the conjunction is false.

The number of possible truth value combinations depends upon the number of sentences one starts with and also upon the fact that there are two truth values, true and false. Thus, determination is through 2^3 where 'r' stands for the number of sentences. In the above conjunction, there were three sentences, p, q, r, and so 2^3 or 8 possible truth value combinations.

1.4. Alternation is a truth functional operation by which two or more sentences are transformed through linking by 'either ... or ... or both'. 'Unless' is taken as equivalent to 'either ... or ... or both'. An example of the formation of an alternation is the linking of the two sentences,

1.4.1. learning is self-developmental
1.4.2. learning is status quo supportive

by 'either ... or ... or both' as follows:

1.4.3. either learning is self-developmental or learning is status quo supportive

they are linked by 'if ... then ...'

1.5.3. if the frequency of teacher-student interaction increases then teacher-student liking increases

These sentences can be symbolized as follows:

1.5.1. p
1.5.2. q
1.5.3. p→q

where 'p' stands for the frequency of teacher-student interaction increases
'q' stands for teacher-student liking increases
'→' stands for if ... then ...

('→' is an equivalent symbol to '⇒')

The following is the truth table for conditionality:

<table>
<thead>
<tr>
<th>p</th>
<th>q</th>
<th>p→q</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>T</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>T</td>
</tr>
</tbody>
</table>

This table indicates that the conditional is false if and only if the antecedent is true and the consequent is false. It is true in all other cases.

1.6. Biconditionality is a truth functional operation through which two sentences are linked by 'if and only if ...'. For example, to form a biconditional the sentences,

1.6.1. learners are motivated
1.6.2. learners achieve

are linked by 'if and only if ... then ...' as follows:

1.6.3. if and only if learners are motivated then learners achieve

These sentences are symbolized as follows:
1.6.5 easily can be seen as an expansion of 1.6.3.

1.7. Validity of sentences containing truth functional operators consists in their coming out true, under all interpretations of the truth values of their component sentences. For example, \( p \land p \) is valid, since

\[
\begin{array}{|c|c|}
\hline
p & p \\
\hline
T & T \\
\hline
\end{array}
\]

The concept of validity is important in deductive reasoning. Truth functional transformation rules of a deductive system are valid schemes. Application of these valid schemes permit one to determine whether propositions are implied by premises. What is basic to such application is the following:

Premises imply conclusion if and only if no interpretation of the truth values make the premises true and the conclusions false. In other words, implication is the validity of the conditional in which the antecedent is the premise or conjunction of the premises and the consequent is the conclusion or the conjunction of the conclusions.

To illustrate: the deduction of \( r \supset q \) from \( p \supset q \) and \( q \supset p \) is established because \( (p \supset q) \land (q \supset p) \supset (r \supset q) \) is valid. A truth table shows that \( (p \supset q) \land (q \supset p) \supset (r \supset q) \) is true under all interpretations.

\[
\begin{array}{|c|c|c|c|}
\hline
p & q & r & (p \supset q) \land (q \supset p) \\
\hline T & T & T & T \\
T & T & T & T \\
T & F & T & T \\
T & F & T & T \\
F & T & T & T \\
F & T & T & T \\
F & F & T & T \\
F & F & T & T \\
\hline
\end{array}
\]

The decision procedure of Quine is more elegant:

\[
\begin{array}{|c|c|c|c|}
\hline
p & q & r & (p \supset q) \land (q \supset p) \\
\hline T & T & T & T \\
T & T & T & T \\
T & F & T & T \\
T & F & T & T \\
F & T & T & T \\
F & T & T & T \\
F & F & T & T \\
F & F & T & T \\
\hline
\end{array}
\]

1.8. Equivalence is mutual implication. Obviously, mutual implication is the validity of the biconditional. For example, the equivalence of \( p \supset q \) to \( (p \supset q) \land (q \supset p) \), stated in 1.6, can be shown through the validity of the biconditional.

\[
\begin{array}{|c|c|c|c|c|}
\hline
p & q & (p \supset q) \land (q \supset p) \\
\hline T & T & T \\
T & F & T \\
F & T & T \\
F & F & T \\
\hline
\end{array}
\]

True under all interpretations; therefore, valid.

2. Quantification Syntaxes

2.1. Conclusions may be inferred necessarily from premises provided the rules of a valid syllogism are met. Inference in syllogisms depends upon the finer substructures not upon the broad outward structures of sentences expressing propositions. In truth functional syntaxes, presented in 1, implication was based upon outward structure.

Consider the syllogism,

2.1.1. Nothing valuable is status quo supportive

2.1.2. Some learning is status quo supportive

2.1.3. Therefore, some learning is not valuable

which is schematically

2.1.1. No P is M

2.1.2. Some S is M

2.1.3. Therefore, some S is not P

'S', 'P', and 'M' stand not for sentences but for terms. Terms are the finer substructures. Since terms do not have truth values but have extensions or are true or false of individuals, syllogistic syntaxes is needed over and beyond

truth functional syntaxes.

2.2. The argument in 2.1 is a syllogism because it consists of three categorical sentences--two of which are premises and one of which is a conclusion--and contains three terms--the subject term, S, the predicate term, P, and the middle term, M.

Categorical sentences are of four kinds:

A: All S is P

E: No S is P

I: Some S is P

O: Some S is not P

A and E are universal, while I and O are particular. A and I, of course, are affirmative, and are called 'A' and 'I', since these are the first two vowels of 'affirmo,' which means I affirm. 'Nemo' means I deny, and so its vowels 'E' and 'O' stand for negative categorical sentences.

In the syllogism above, the premises are E and I, and the conclusion is O.

2.3. There are 256 possible forms of the syllogism, for there are 4 syllogistic figures and 64 moods. The figures arise from the different ways of arranging the terms in a syllogism, and are the following:

Figure 1 Figure 2 Figure 3 Figure 4

| MP | PM | MP | MP |
| SM | SM | SM | SM |
| SP | SP | SP | SP |

The moods arise from the fact that there are four kinds of categorical sentences and three in a syllogism. 4 \times 3 = 12.

1. The moods are as follows:

| AAA | AIA | EAA | EIA | IAA | IIA | IIA |
| AAE | AIE | EAR | EIR | IAE | IRE | IIE |
| AAI | AII | EAI | EIA | IAI | IAI | IAI |
| AAO | AIO | EAO | EIO | IAO | IAO | IAO |
| AXA | AOA | EAX | EOA | IAX | IAX | IAX |
| AEE | AOE | EEE | EOE | IEE | IEO | EEE |
| AAI | AOI | EAI | EIO | IAI | IEO | EAI |
| AEO | AOO | EAO | EOO | IAO | IEO | EOE |

The moods are as follows:

| AAA | AIA | EAA | EIA | IAA | IIA | IIA |
| AAE | AIE | EAR | EIR | IAE | IRE | IIE |
| AAI | AII | EAI | EIA | IAI | IAI | IAI |
| AAO | AIO | EAO | EIO | IAO | IAO | IAO |
| AXA | AOA | EAX | EOA | IAX | IAX | IAX |
| AEE | AOE | EEE | EOE | IEE | IEO | EEE |
| AAI | AOI | EAI | EIO | IAI | IEO | EAI |
| AEO | AOO | EAO | EOO | IAO | IEO | EOE |
The syllogism presented in 2.1 is Figure 2, Mood EIO.

2.4. Some terms of the categorical sentences are distributed, i.e., refer to every member of the class, while some are not. Where ‘D’ stands for distributed and ‘U’ stands for undistributed, the following holds:

<table>
<thead>
<tr>
<th>Kinds of Sentences</th>
<th>Subject Terms</th>
<th>Predicate Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>D</td>
<td>U</td>
</tr>
<tr>
<td>E</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>I</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>O</td>
<td>U</td>
<td>D</td>
</tr>
</tbody>
</table>

2.5. A syllogism is valid if and only if the following rules are met:

2.5.1. The middle term must be distributed at least once.

2.5.2. If a term is distributed in the conclusion, it must be distributed in the premises.

2.5.3. From two negative premises, no conclusion can be drawn.

2.5.4. From two particular premises, no conclusion can be drawn.

2.5.5. If one premise is negative, the conclusion must be negative.

2.5.6. If one premise is particular, the conclusion must be particular.

To avoid having to apply the rules, in medieval times code names were devised to remember the valid forms of syllogisms. The code names were as follows:

<table>
<thead>
<tr>
<th>Figure 1</th>
<th>Figure 2</th>
<th>Figure 3</th>
<th>Figure 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barbara</td>
<td>Cesare</td>
<td>Darapti</td>
<td>Fresioen</td>
</tr>
<tr>
<td>Celarent</td>
<td>Camestres</td>
<td>Darapti</td>
<td>Grammatic</td>
</tr>
<tr>
<td>Darii</td>
<td>Festino</td>
<td>Dionisius</td>
<td>Camestres</td>
</tr>
<tr>
<td>Ferio</td>
<td>Baroco</td>
<td>Ferson</td>
<td>(AEO)</td>
</tr>
<tr>
<td>(AAI)</td>
<td>(EO)</td>
<td>Telcisco</td>
<td>(AEO)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bocarco</td>
<td></td>
</tr>
</tbody>
</table>

The vowels indicate the mood, e.g., Barbara is AAA. No names free variable is one that is not governed by a quantifier.

The final rule, TF, already has been explicated in 1.7.

2.10. In summary, conclusions may be inferred necessarily from true premises if and only if the rules set forth in 2.9 are met. Two deductions will be presented to illustrate the use of the rules. The implication established in 1.9 can be set forth as the following deduction:

\[
\begin{align*}
1 &. p \rightarrow q \\
2 &. r \rightarrow p \\
3 &. r \rightarrow q (1 \cdot 2) TF \\
4 &. (p \rightarrow q) (r \rightarrow p) \rightarrow (r \rightarrow q) \\
\end{align*}
\]

The first star stands for suppose and the succeeding stars indicate conclusions of the initial premises. Thus, 3 is implied by 1 and 2. The implication is recorded as a valid conditional, since implication holds if and only if the conditional formed with the premises as antecedent and the conclusion as consequent is valid and the implication was established by rules. When the implication is recorded as a valid conditional, the star is left behind to show that the line holds absolutely and not relative to another line. The numbers on the left are for reference and on the right for reference back. On the right, the rules that justify the steps are cited. In this deduction only one rule was utilized, truth functional inference (TF), since finer structures of the sentences were not involved. However, in the next deduction more rules than TF are utilized, since the deduction involves terms.

This deduction is the one cited in 2.6 and it may be established as follows:

\[
\begin{align*}
1 &. (3y)(Ey \cdot (x)(Gx \supset Hxy)) \\
2 &. (x)(Gx \supset Hxy) \quad (1) EI Y \\
3 &. Gy \quad (2) TF \\
4 &. (x)(Gx \supset Hxy) \quad (3) TF \\
5 &. Gx \supset Hxy \quad (4) UI \\
6 &. Gx \\
7 &. Gy \supset Hxy \quad (3 \cdot 5 \cdot 6) TF \\
8 &. (3y)(Ey \cdot Hxy) \quad (7) EG \\
9 &. Gx \supset (3y)(Ey \cdot Hxy) \\
10 &. (x)(Gx \supset (3y)(Ey \cdot Hxy)) \quad (9) UG x \\
11 &. (3y)(Ey \cdot (x)(Gx \supset Hxy)) \supset (x)(Gx \supset (3y)(Ey \cdot Hxy)) \\
\end{align*}
\]

It should be noted that on the right hand side when the rules that demand flagging are used, i.e., EI and UE, the variables so flagged are cited so that one can check whether the variables are flagged only once and each is alphabetically later than all the other free variables of the schema it flags. In this deduction, y and x are the flagged variables as cited in 2 and 10 and they do meet the requirements. Also, in this deduction, there is a deduction within a deduction--0 is implied by 6--as indicated by the double stars.
APPENDIX II

This appendix will present the translation of the syntactical symbols used in the SIGGS Theory Model.

Logico-mathematical Symbols  Verbal Symbols
1. $\text{df}_n$ ... equals by definition ...
2. $\{\ldots\}$ set of elements ...
3. $\ldots | \ldots$ such that ...
4. $\ldots \subseteq \ldots$ is less than or equal to ...
5. $\ldots \land \ldots$ and ...
6. $\ldots \supset \ldots$ is greater than or equal to ...
7. $\ldots = \ldots$ is equal to ...
8. $\ldots (\ldots)$ that such that ...
9. $\ldots \in \ldots$ is an element of ...
10. $\exists (\ldots)$ there is a ... such that ...
11. $\ldots < \ldots$ is less than ...
12. $(\ldots, \ldots, n)$ n-tuple of ... and ... and n
13. $(\ldots) \ldots$ at ...
14. $\ldots < \ldots$ precedes ...
15. $\ldots \rightarrow \ldots$ plus ...
16. $\ldots \subset \ldots$ is contained in ...
17. $\ldots \times \ldots$ Cartesian product of ... and ...
18. $\not\in \ldots$ is not equal to ...

$\sum_{e \in \ldots} \ldots$ summation of ... as e varies over ...

$\ldots \vdash \ldots$ ... yields ...

for all ... ...
... only if ...
... is not an element of ...
... is equivalent to ...
either ... or ... and not both
power set of ...
complement of ... with respect to ...
cardinality of ...
absolute value of ...
increment of ...
... minus ...
maximum ...
union of ... where ... is indexed from 1 to n
union of ... and ...
conjunction of ... where ... is indexed from 1 to n
intersection of ... and ...
... is greater than ...
... into ...
summation of ... where ... is indexed from 1 to n
union of ... as e varies over ...

APPENDIX III

The SIGGS Theory Model is presented as follows

1. citation of term which takes the form, $n \ldots , \ldots$
   where 'n' stands for a number which indicates order of presentation
   '...' stands for a term
   '...' stands for a symbol for the respective term

2. definition of term, unless term is primitive, which takes the forms,
   2.1. natural language definition which takes the form, $n.1. \ldots \text{ is } \ldots$
   where '1' stands for a natural language
   '...' stands for a definendum
   '...' stands for a definition
   2.2. logico-mathematical definition which takes the form, $n.2. \ldots \text{df } \ldots$
   where '2' stands for a logico-mathematical
   'df' stands for equals by definition

1. universe of discourse,
2. component, s
3. group, G
   3.1. A group is at least two components that form a unit within the universe of discourse.
   3.2. $G \text{ df } \{ e | 1 \leq i \leq n \land a \in \{ 2 \} \}$
4. characterization, CH
5. Information. I

5.1. Information is characterization of occurrences.

5.2. I = \text{DF } CH \mid CH = \{c \mid t(p((c,v)) \in p)\}

5.3. Selective information. Is

5.3.1. Selective information is information which has alternatives.

5.3.2. I^g = \text{DF } I \mid \exists c(v) \in p \land 0 < v \land v < 1

5.3.1.1. Nonconditional selective information. Is

5.3.1.2. Nonconditional selective information is selective information which does not depend on other selective information.

5.3.2.1. Conditional selective information. Is

5.3.2.2. Conditional selective information which depends upon other selective information.

6. Transmission of selective information. \{I^g_1, I^g_2, \ldots, I^g_n\}

6.1. Transmission of selective information is a flow of selective information.

6.2. \{I^g_1, I^g_2, \ldots, I^g_n\} = \text{DF } T(I^g_1(t_1), I^g_2(t_2), t_1 < t_2 + 1)

6.2.1. \{I^g_1, I^g_2, \ldots, I^g_n\} = \text{DF } T(I^g_1(t_1), I^g_2(t_2), t_1 < t_2 + 1)

7. Affect relation. Ra

7.1. An affect relation is a connection of one or more components to one or more other components.

7.2. Ra = \text{DF } R \mid R \subseteq S \times S \land R \neq \emptyset \land y = y

8. System. S

8.1. A system is a group with at least one affect relation which has information.

8.2. S = \{a, \ldots, b, \ldots, R \subseteq S \times S \land \exists y = y \in R \land S \subseteq S \land y \subseteq S\}


9.1. A negatystem is the components not taken to be in a system.

9.2. S = \{c, \ldots, c, \ldots \neq \emptyset

10. Condition. C

10.1. Condition. C

11. System state. Stg

11.1. A system state is a system’s conditions at a given time.

11.2. Stg = \text{DF } E \mid E(t) = E(t)

12. Negatystem state. Stg

12.1. A negatystem state is a negatystem’s conditions at a given time.

12.2. Stg = \text{DF } E \mid E(t) = E(t)

13. System property. Pg

13.1. A system property is a system’s conditions.

13.2. Pg = \text{DF } E \mid E(S)

14. Negatystem property. Pg

14.1. A negatystem property is a negatystem’s conditions.

14.2. Pg = \text{DF } E \mid E(S)

15. Value. V

16. System property state. Stg

16.1. A system property state is a system property’s value at a given time.

16.2. Stg = \text{DF } V \times P(V(Pg(t)))

17. Negatystem property state. Stg

17.1. A negatystem property state is a negatystem’s property’s value at a given time.

17.2. Stg = \text{DF } V \times P(V(Pg(t)))

18. System environment. Eg

18.1. System environment is a negatystem of at least two components with at least one affect relation which has selective information.
50. Integration, IG
50.1. Integration is wholeness under system environmental change.
50.2. IG ≡ (∀t) STW(t + Δt) − STW(t) | ∃ 1 ≤ i ≤ EC

51. Hierarchical order, HO
51.1. Hierarchical order is levels of subordination of components in each level with respect to affect relations.
51.2. HO ≡ ∃ 2 DA(RA C A ∧ YRA C n DA) = RA = (u; R1) U (v; R2) ∧ (R1 ∩ R1+1 = i = 1 ∧ i = 1) ∧ n+1 R1 ∩ R1+1 = R1 ∩ R1 = 0) ∧ u = (R1 ∩ R1+1 ∧ j+1 i = 1) ∧ SR(R1) ∧ (∃ (D(R1) C R(D1) ∩ R(R1) C D(R1+1) ∩ R(R1) # R(j)))

52. Flexibility, F
52.1. Flexibility is different subgroups of components through which there is a channel between two components with respect to affect relations.
52.2. F ≡ (∃ 3 DA(3A C A ∧ YDA(RA C n DA) = Σ 0< i < 1 ∧ S = YR A; (S2 ∩ 2) C R A = 3S′(S′ ∈ A ∧ 3S′ C S ∧ S′ = 1) ∧ 3(n > 1 ∧ 1 < i < 3 ∧ a; 2 OR; 3 ∧ SR(R1) = (R1 ∩ R1+1 ∧ j+1)

53. Homomorphism, HM
53.1. Homomorphism is components having the same connections as other components.
53.2. HM ≡ 3′(S′ C S ∧ 3′(S′ C S ∧ 3(n ≥ 1 ∧ S′ = S′))

54. Isomorphism, IM

54.2. IM ≡ 3′(S′ C S ∧ 3′(S′ C S ∧ 3(n ≥ 1 ∧ S′ = S′))

55. Automorphism, AM
55.1. Automorphism is components whose connections can be transformed so that the same connections hold.
55.2. AM ≡ 3′(S′ C S ∧ 3′(S′ C S′))

56. Compactness, CO
56.1. Compactness is average number of direct channels in a channel between components.
56.2. CO ≡ (∃ 3′ DA(RA C A ∧ YRA C n DA) = n DA = (u; R1) U (v; R2) ∧ (R1 ∩ R1+1 = i = 1 ∧ i = 1) ∧ n+1 R1 ∩ R1+1 = R1 ∩ R1 = 0) ∧ u = (R1 ∩ R1+1 ∧ j+1 i = 1) ∧ SR(R1) ∧ (∃ (D(R1) C R(D1) ∩ R(R1) C D(R1+1) ∩ R(R1) # R(j)))

57. Centrality, CE
57.1. Centrality is concentration of channels.
57.2. CE ≡ 3A(A C S ∧ YR B ∈ S = 3′ DA(3A C A ∧ YR DA(RDA C n DA) = ∑ 4 OR DA (B ∈ n 4 OR DA (A))))

58. Size, SZ
58.1. Size is the number of components.
58.2. SZ ≡ 3′(S1; 1 ≤ n)

59. Complexity, CX
59.1. Complexity is the number of connections.
59.2. CX ≡ (∃ 3′(R1 ∨ RA))

60. Selective Information, SI
60.1. Selective information is amount of selective information.

73. Strain, SA
73.1. Strain is change beyond certain limits of system state.
73.2. SA ≡ 15 STW(t + Δt) − STW(t) | ≥ 3

The descriptions in the model are of two kinds: indirect ones required for direct description of any system which are presented through primitive terms (undefined terms) and defined terms, and direct ones describing any system which are presented through defined terms. Table 1 is a list of the former, while Table 2 is a list of the latter. These tables are on the pages to follow.
| 8. system, S | 13. system property, Pg |
| 11. system state, Stg | 10. system property state, Stg |

**PROPERTIES**

| 16. system environment, Eg | 48. interdependency, ID |
| 17. system environment of change, Ecg | 49. wholeness, W |
| 22. topic, TP | 50. integration, IG |
| 23. input, IP | 51. hierarchical order, HO |
| 26. storeup, SP | 52. flexibility, F |
| 27. feedin, FI | 53. homomorphism, HM |
| 28. feedback, FD | 54. isomorphism, IM |
| 29. feedthrough, FT | 55. automorphism, AM |
| 30. feedback, FB | 56. compactness, CO |
| 31. filtration, FL | 57. centrality, Cz |
| 32. spillage, SL | 58. size, SS |
| 33. regulation, RG | 59. complexity, CX |
| 34. comparability, CP | 60. selective information, SI |
| 35. openness, O | 61. size growth, SG |
| 36. adaptability, AD | 62. complexity growth, XG |
| 37. efficiency, EF | 63. selective information growth, TD |
| 39. complete connectivity, CC | 64. size degeneracy, ZD |
| 40. partialness, P | 65. complexity degeneracy, XD |
| 41. uniqueness, U | 66. selective information degeneracy, TD |
| 42. connectedness, DC | 67. stability, SB |
| 43. vulnerability, VN | 68. state steadiness, SS |
| 44. passive dependency, Dp | 69. state determinacy, SD |
| 45. active dependency, Da | 70. equifinality, EL |
| 46. independency, I | 71. homeostasis, HS |
| 47. segregation, SG | 72. stress, SE |
| 73. strain, SA |

Table 2: Direct System Descriptions

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