METHODOLOGY OF THEORY BUILDING

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To

Teresa Steiner Schwartztrauber

because she is a sister who inspired autonomy

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INTRODUCTION

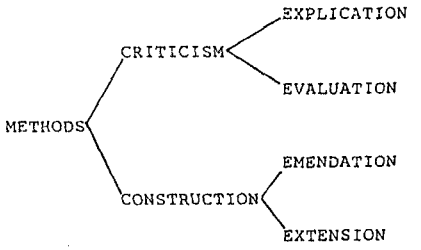
This is a how-to-do book. In it I shall present the methods of building theory. But the methods will not be bound to mindless routine, rather to intelligent usage. By setting forth the methods in the context of the logic of theoretical knowledge, understanding of the methods will be emphasized throughout.

One does not build theory from scratch, for theorizing has been going on at least since the time of the Pre-Socratics. 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 or this act of discernment ('criticism' arises from the Greek 'krinein' meaning to discern) is 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 of criticism: explication and evaluation, and the two of construction: emendation and extension. Schema 1, on the next page, summarizes this.



Schema 1: Methods Involved in Theory Building

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 kinds 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

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 theory building, particularly to those students interested primarily in theory about human social life. Most were interested 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

1. RECOGNIZING THEORY

'Theory' is derived from the Greek 'theoria' which means contemplation or speculation. In a popular sense then one's theory is one's speculation or conjecture about something. For example, it is not uncommon to hear a teacher say that her or his theory is that a student is failing due to a bad home. However, such a popular sense does not catch up the technical sense of 'theory' in 'Einstein's theory of relativity', 'Dewey'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 praxis (acting). Theoria consists of rational activities related to knowledge of universals, while praxis consists of rational activities related to moral activity (agibilia) and artistic activity (factibilia). Artistic activity is not limited to a making for its own sake (fine or intrinsic arts) but also includes useful making as well (functional or instrumental arts). Making a hoe to till the soil is clearly a functional or instrumental making, while making an abstract design in line and color on a canvas is a fine or intrinsic making. The former is art for the sake of something else; the latter is art for the sake of itself.

Since 'theory' (when theory meets certain standards) is the term for the knowledge achieved through theoria and 'practice'is the term for the activity achieved through praxis, theory may be differentiated from practice. In this sense it is impractical; it is non-practical. Nevertheless, theory does have a bearing upon practice; it provides principles for practice. These principles can be used in practice, provided a developmental bridge is provided. In other words, it is correct to say "it is all right 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.

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 psychical state in which one has certitude about something and has a right to that certitude. That is to say, it is a state of true belief. Knowledge, however, is recorded knowing; it is the body of expressed certitudes and rights thereto. Knowledge is the body of expressed true beliefs. Because theory that meets certain standards is knowledge and so part 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.

Theoretical fact is a certain kind of fact; it is fact about universals. Universals are forms or essences. For example, theoretical fact about learning is fact about what is common to all occurrences of learning no matter where or when they occur. Theoretical fact sets forth the essential characteristics or properties of learning. That a change in behavior is an essential characteristic of learning is not a theoretical fact; that a change in psychical state is an essential characteristic of learning is a theoretical fact. Theoretical knowing of learning 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 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 did not appear on planet earth until approximately a million years ago. If they had appeared earlier, they would have been included just as any human anywhere in the universe at any time is included. But if the limitation is in terms of time and place, as in learning at Indiana University, the class is individual not universal.

But it is not enough for theoretical knowing to know the essential properties of learning. Also one must know the essential and accidental relations between the universals. To illustrate: attention bears an essential relation

to learning, while practice bears an accidental one. Essential relations are internal ones, that is, they are inherent and so necessary. Learning would not be learning without an relation to an attention state. Accidental relations are external ones and so not necessary. Learning still would be learning without being related to practice.

In summary, complete theoretical fact is fact about essential properties and their relations. Such complete 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 as opposed to particular or singular statements. Generalizations are all-statements and so refer to every one of the elements of a class. Particular statements are some-statements and so refer not to all elements but to at least one non-specified element of a class. Singular statements are this-statements and so refer to one 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 'law' because 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 differential treatment appears to be level of generality of the universal statements. To illustrate: the lower-order generalization $PV = k$ is called 'Boyle's Law', while the higher-order generalizations from which it is inferred are called 'the Kinetic Theory'. All true universal statements, no matter their level of generality, are lawlike.

Yet it does not make logical sense to refer to a natural law taken by itself as theory. Theory that is knowledge is a system of lawlike statements. Consequently, universal statements are interrelated to form a whole. For example, 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 a heap of lawlike statements cannot pretend to knowledge. As we have seen above, to have theoretical knowledge is to have theoretical fact about essential properties and their relations. Such theoretical fact can be represented only through a system of statements. 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 lawlike 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 that 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 function. Structure is the content and form of anything. Thus, the structure of a building is its materials and the way they are arranged. The structure is determined by what the building is to do. 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 a criterion or criteria; no 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, 'theory' without a modifier 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 ought not to occur.

To begin, something that bears a similarity to something else is said to be a model. For example, an airplane built by a small boy from a kit for a Bede 4 is a model-of an actual four passenger mono-wing plane. Notice this is a model-of. Undoubtedly there were more than one model-for the Bede 4 that preceded its actual manufacture in order to prove its design. These models, of course, were physical ones. But also there can be conceptual models, either of or for. 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 praxis referred to earlier. It is through rational activities, 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 like it in form, it is a formal interpretation of the mathematics. Second, when theories are radical departures from previous theory or not fully established theories, they are called by some 'models'. This calling is based upon the lack of distance of the theory from its theory-model, i.e., from the theoretical model which is the well known and 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 devised. To do so, confuses 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 theory. To recognize 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 indiivdual 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, then 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. This 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 parcelled out, in the same way as knowledge.
>
> THEAETETUS. How so?
>
> STRANGER. Knowledge also is surely one, but each part of it that commands a certain field is marked off and given a special name proper to itself. Hence language 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 may consist of a simple difference of <u>object</u>, or of the <u>source of knowledge</u>, or of the <u>kind of knowledge</u>, or perhaps of all three together. On this characteristic, therefore, depends 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. Just as 'philosophy' can be used to encompass all of knowledge. 'Philosophy' in 'Doctor of Philosophy' is such an encompassing sense. I shall eliminate this confusion by following contemporary practice and restricting the sense of both 'science' and 'philosophy'. An example of such restriction of 'philosophy' would be the second 'philosophy' on my diploma which reads:

Doctor of Philosophy
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 technical sense and so in a non-exclusive sense. A phenomenon, thus, could be given meaning in terms of more than one alternant. This non-exclusivity is necessary, since phenomena that can be given meaning as living phenomena also can be given meaning as physical phenomena, and phenomena that can be given meaning as human phenomena also can be given meaning as living and as physical phenomena. However, it is the case that phenomena that can be given meaning as living would be given incomplete meaning through the physical alone; and it is the case that phenomena 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 meaning thus is incomplete. 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 such is the subject of metaphysics. 'Metaphysics' derives from the Greek meta ta physika and received its name through 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 work on nature, entitled 'Physics', and so ta meta ta physika biblia (the books after the books on nature). The position about the nature of reality taken in metaphysical materialism is that reality is matter and matter alone. Thus, for Skinner, mind or the psyche is ruled out. All of human phenomena can be given meaning in terms of organic states. The 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 to only a part of human phenomena, the origin and development of the human being both in the physical sense (Physical 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 is a human phenomenon, 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 no intentionality, and also learning can involve guidance or non-guidance of the learner. Thus, learning can be either non-intended and non-guided, non-intended and guided, intended and non-guided, and intended and guided. Learning that is non-intended I take to be a phenomenon only in the physical and biological sense. That is to say, where there is no consciousness, there is no phenomenon in the human sense.

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. Vicarious learning can be viewed as indirect learning insofar as learning takes place through imaginative participation in the experiences of another. Incidental learning, on the other hand, is direct but it is a minor concomitant of other learning. Both vicarious learning and incidental learning need not be fortuitous; either could be intended or guided.

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

Both fortuitous learning and training should be ruled out as education, since human learning is not involved where learning is non-intended. But should education be used for all intended learning? Dewey thought so, for he conceived "education as a process of forming dispositions, intellectual and emotional toward nature and fellow men" (1916, p. 383). Education, for him, was taking place in all our transactions with society. "When self-hood is perceived to be an active process, it is also seen that social modifications are the only means of changed personaiities." (1950, p. 154) Dewey's conception does make education as broad as human life, for the formation of human life is human learning. It is coming to meaning. It is being able to give significance to objects appearing as phenomena. It is being able to use signs. [Peirce defines 'sign' as "something that stands to somebody for something in some respect or capacity" (COLLECTED PAPERS, 2.228).] But giving significance involves not only an I giving meaning and so intentionality,

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

Since 'education' is derived from the Latin 'educo' to lead out, I take education, not in Dewey's sense, but in the sense of both intended and guided learning. I use the term 'discovery' to characterize learning that is intended but not guided. Doing research would be a kind of discovery learning; a disciplined discovery learning. This, of course, does not make education as broad as human learning but restricts education to guided human learning. Education, then, becomes the teaching-studenting process. Teaching is a process of guiding learning, and studenting is a learning process of a conscious learner, an I or one intending learning.

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

L,-I,-G	L,-I,G	L,I,-G	L,I,G
fortuitous learning	training	discovery learning	education

where 'L' stands for learning
'I' stands for intended
'G' stands for guided
'-' stands for not

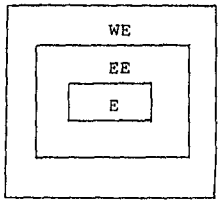
Schema 2: Kinds of Learning

'Learning' besides being used in a process sense, as above, is used in an achievement sense. Consequently, one speaks of someone 'as learned'. The same double usage is seen for 'education'. To eliminate ambiguity, it should be noted that 'learning' and 'education' in the achievement sense adds effectiveness to 'learning' and 'education' in the process sense. The process of learning or the process of education is effected or realized. 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 'education' 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 or good in and of itself; it is not intrinsically good. Only education that is effective in producing good human beings is worthwhile, is 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.



where 'WE' stands for worthwhile education
'EE' stands for effective education
'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 schooling. Wherever there is a teaching-studenting process, there is education. So education often takes place in the home, in the church, in industry, and elsewhere besides the school.

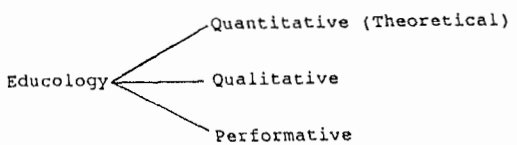
Just as other divisions of knowledge are given names, I gave knowledge of education the name 'educology' (1964). This name was introduced, since 'pedagogy,' the term in use, is inadequate. 'Pedagogy' is inadequate for at least two reasons. First, 'pedagogy' has become, especially in the United States, a perjorative term because it has become associated with pedantry, book learning without understanding but with display. Secondly, 'pedagogy' is associated with the education of children, for the pedant in Greek times was the slave who walked the children to and from their lessons,

and watched them at their lessons to see that they did what they were supposed to do.

Another possible name for the study of education is androgogy'. But this term was introduced for the study of adult education. I see no reason why the term was so restricted unless one takes 'man' only in the sense of adult man. But why do so? But there is another difficulty. 'Androgogy' is limited to males and so is a sexist term. 'Andros' means man in distinction to 'gyne' meaning woman (consider the term 'androgynous'). If one desires a term for the study of adult education, 'adult educology' is perfectly good and indicates that adult educology is a branch of the general study of education which is educology.

Not all cognition is theoretical in nature. There are qualitative and performative cognitive structures as well. Qualitative structures differ from theoretical structures insofar as the latter are quantitative. Theoretical structures allow one to shape and group instances; they are universals and so are generals 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 sensitive to the immediacy of the given, to the uniques; they are pervasive qualities. Uniques cannot be members of classes and so no extension is involved; each is what it is. It cannot even be said of an unique that it is one of a kind. No categorization is possible. Performative structures are enactions. They allow one to act.

It follows from the above discussion of kinds of cognition that adequate theory of education is only one branch of knowledge of education. Since theoretical cognition is quantitative, when it is adequate theoretical cognition it can be expressed as quantitative educology. See Schema 4 which follows.



Schema 4: Branches of Educology

On the basis of the object of knowledge, theory of education is hominological. 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 experience.

Kant also sorted theory on the basis of what he called 'kind' into analytic theory and synthetic theory.

> . . . there is in them a distinction according to content, by virtue of which they are either merely explicative and add nothing to the content of knowledge, or ampliative and enlarge the given knowledge; the former can be called 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 when they are not applied, when they are pure, do not add to the content of knowledge. They are the disciplines of formal knowledge. For example, pure geometry is formal knowledge. Einstein stated well the analytic or formal nature of geometry: "geometry . . . is not concerned with the relation of the ideas involved in it to objects of experience, but only with the logical connection of these ideas among themselves." (p. 2)

Synthetic theory, on the other hand, is not theory of form but of content. It's main business is to add to the content of knowledge. Science, praxiology, and philosophy consist of theory of content.

When we crossover the two classifications of theory, three classes of theory emerge: a priori analytic, a 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 contradictory, and so must be ruled out. Since analytic theory is of form and not of content, it cannot treat of experience. Since what does not treat of experience cannot have its truth ascertained in experience, the analytic cannot be

a posteriori.

	analytic	synthetic
a priori	a priori analytic	a priori synthetic
a posteriori		a posteriori synthetic

Schema 5: Classes of Theory Based on Kant

We have already pointed out that mathematics and logic in their syntactical dimensions are analytic, while science, praxiology, and philosophy are synthetic. But we have not considered the a priori-a posteriori dimension relative to each discipline.

To begin with the formal disciplines, mathematics and logic in their syntactical dimensions consist of statements that are necessary; their truth depends only upon reason. An example familiar to most would be Euclidean geometry. Recall that the truth of the Pythagorean theorem (the sum of the squares of the lengths of the sides of a right triangle is equal to the square of the length of the hypothenuse) depends upon whether a relationship of implication holds between the axioms and the theorem. One must be able to deduce the theorem from the axioms. In this case, the origin of the sense of 'a priori' in Aristotelian ideas can be seen clearly: the theorem is established on the basis of what is prior in knowledge, on the basis of the axioms. Such a prior relationship cannot be noted with respect to all a priori truth, since the concept of a priori has had considerable development since the Scholastics introduced the concept in the context of Aristotle's ideas.

Science and praxiology differ from philosophy insofar as both science and praxiology are a posteriori synthetic while philosophy is a priori synthetic. This difference will become clearer in the subsequent discussion of science, praxiology, and philosophy.

Philosophy is synthetic insofar as philosophy characterizes essential properties and essential relations between properties. Let us consider first that part of philosophy of education which characterizes the essential properties of education. Since this part of philosophy of education

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-studenting process. As such a learning process, it has four basic properties. First, education must be characterized as having a teacher, one who guides the learning. Secondly, education must be characterized as having a student, a learner who is self-aware, i.e., conscious and so intending. These two properties of education are obvious from education as a teaching-studenting process. Since education is a human learning process, a third basic property emerges. There must be a content to be learned, i.e., signs for psychical structuring. Finally, any process has a 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 more importantly is 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 of education is, and what context for human guided learning is. A set of descriptors is provided so 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. Schema 6 that follows presents the outline or a map of descriptive metaphysics of education.

$$E = T \cup S \cup C \cup X$$

$$T = T_1 \cup T_2 \cdot \cdot \cdot \cup T_n$$

$$S = S_1 \cup S_2 \cdot \cdot \cdot \cup S_n$$

$$C = C_1 \cup C_2 \cdot \cdot \cdot \cup C_n$$

$$X = X_1 \cup X_2 \cdot \cdot \cdot \cup X_n$$

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

Schema 6: Map of Descriptive Metaphysics of Education

An example of an attempt at descriptive metaphysics of education would be Bloom's, although he was not clear about the task he was engaged in and it was not done adequately. In his taxonomies, Bloom attempted to set forth objectives of education. In other words, what he was doing was characterizing the essential properties of intrinsically good student achievement.

He was not clear about the task, for he seemed to believe that he was providing a classification for extant objectives of education. "We found that most of the objectives stated by teachers in our own institutions, as well as those found in the literature, could be placed rather easily in one of three major domains of classifications: [cognitive, affective, and psychomotor]." (1956, p. 6) However, what teachers take to be the learning outcomes may or may not be essential properties of student achievement, and so essential to education. What is essential in education is not necessarily a matter of consensus among teachers. The majority may or may not intellectually grasp the essential properties of education. Also the task was not done adequately, due to misconception of psychical development. Cognitive development was limited to the quantitative, and the quantitative was limited to the experiential which can be related to the sensory. Thus, philosophical psychical development was ruled out as cognitive and reduced to the affective, as was qualitative cognition. Performative cognition too was excluded with some reduced to psychomotor development and the remainder ignored entirely. Conative development was not distinguished from affective and went, to a large extent, unrecognized.

An example of a classification of educational objectives which recognizes all three dimensions of the cognitive--quantitative, qualitative, and performative--is that of G. Maccia (1973).

Descriptive metaphysics constitutes what is called by some 'descriptive theorizing' as opposed to 'explanatory theorizing'. Walter Wallace in SOCIOLOGICAL THEORY (1970)

makes such a sort. There is sociological theory that defines the social and sociological theory that explains the social. Relative to this distinction, 'description' is taken in the narrow sense of characterizing properties, and so the characterization of relations is excluded. But characterizing relations, whether the relations are essential or contingent, is still description. Undoubtedly, theory that describes relations is called 'explanatory', because such descriptions can be used to explain in the sense of characterizing causal relations.

Some logicians of science, for instance Rudner (1966), take descriptive theorizing not to be theorizing. Given that descriptive theory defines phenomena, it is seen as pre-theoretical in nature. Rudner's position, however, rests upon a positivistic orientation which rejects philosophy, and so descriptive metaphysics, as synthetic knowledge. Positivism is a position that holds that only knowledge that is justifiable in terms of sensory experience is admissible. This, of course, rules out knowledge that is justifiable in terms of intellectual experience. Rudner, of course, is left with an insurmountable difficulty: the justification of the definitions. I shall speak further to justification of definitions in the section on evaluation of theory. Here it suffices to state that positivism must be ruled out as an epistemological position, for it is a position as to the nature of knowledge which eliminates one kind of theory, namely, philosophy.

Sometimes descriptive metaphysics is seen as the result of so-called "naturalistic inquiry". However, this is an ambiguous and, in part, erroneous perception. First, descriptive inquiry is seen as naturalistic, because it is taken to be the natural history stage of inquiry. It is thought that the first or natural history stage of inquiry is the description of phenomena through setting forth their properties, i.e., characterizing the phenomena. The second stage of inquiry is taken as explanation, i.e., setting forth why a phenomena has a property through relating properties to other properties. This conception has truth, but the use of 'natural' renders the theoretician passive when the theoretician is active in constructing signs to interpret phenomena. The theoretician is a subject, but in stating so quantitative knowledge or knowledge of the universal is not rendered an impossibility. Definitions are not an arbitrary matter. Multiple renderings of phenomena, multiple perspectives, cannot all be honored, nor ought they be negotiated. A phenomena has an essence which can be grasped provided one can see it intellectually. This asser-

tion does not settle the nominalist-realist 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 setting forth descriptors. This has led also to calling descriptive inquiry 'qualitative'. However, I have argued above that whenever categories are used, and they are used 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 giveness 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 acknowledgement does not lie rejection of truth for negotiated concensus.

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. However, reason must not be taken in a narrow sense. While deductive reasoning is sufficient to establish essential relations, it is not sufficient 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 <u>a priori</u>. The experience that is referred to in the <u>a posteriori</u> 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 <u>a priori</u>. Hence, all of philosophy is <u>a priori</u>.

Both science and praxiology are <u>a posteriori</u>. Contingent not necessary relations are set forth, and so establishment depends upon inductive reasoning not deductive or intuitive reasoning. Inductive 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.

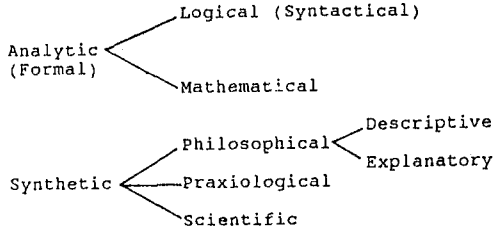
Since a practice is an organized doing, i.e., means interrelated with respect to the production of an end or ends, knowledge of effectiveness would be knowledge of ideals of practice. What we want to know is what means best effect an end or ends.

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 method sometimes 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 developmental 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. What is, is not 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.



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.

	L	M	P		Pr	S
			D	E		
Ph			PhD	PhE	PhPr	PhS
B			BD	BE	BPr	BS
H			HD	HE	HPr	HS

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 hominological.

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 characteritics of each kind of theory so that they can be used as criteria for membership in one of the above fourteen 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.
3.	Is the theory a priori?	Go to 4.	Go to 6.
4.	Is the theory descriptive?	Go to 9.	Go to 5.
5.	Is the theory explanatory?	Go to 12.	Exit.
6.	Is the theory a posteriori?	Go to 7.	Exit.
7.	Is the theory axiological?	Go to 15.	Go to 8.
8.	Is the theory non-axiological?	Go to 18.	Exit.
9.	Is the theory descriptive of physical phenomena?	It is PhD.	Go to 10.
10.	Is the theory descriptive of living phenomena?	It is BD.	Go to 11.
11.	Is the theory descriptive of human	It is HD.	Exit.

	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 PhPr.	Go to 16.
16.	Is the theory about living phenomena?	It is BPr.	Go to 17.
17.	Is the theory about human phenomena?	It is HPr.	Exit.
18.	Is the theory about physical phenomena?	It is PhS.	Go to 19.
19.	Is the theory about living phenomena?	It is BS.	Go to 20.
20.	Is the theory about human phenomena?	It is HS.	Exit.

3. EXPLICATING THEORY

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

'Explication' comes from the Latin '<u>explicare</u>' 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.

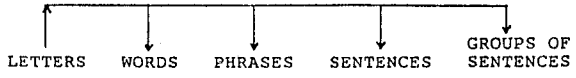
Finally, universal generalizations are related to form systems. An example would be Dewey's theory of education.

Thus, the content of a theory or its parts are: concepts and universal generalizations. Moreover, 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.



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.

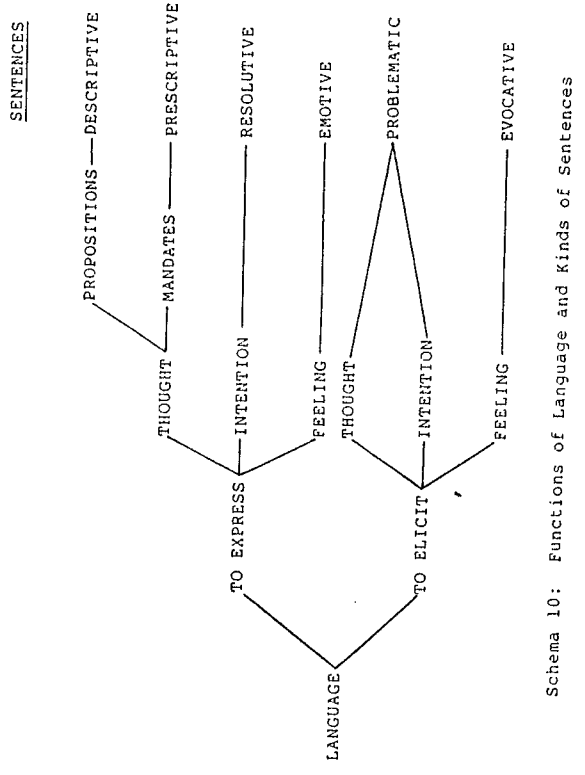
To be more specific in regard to the expressive function of language, examples will be presented and explicated. The sentence

> 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



Schema 10: Functions of Language and Kinds of Sentences

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 why 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', 'bidden', 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.

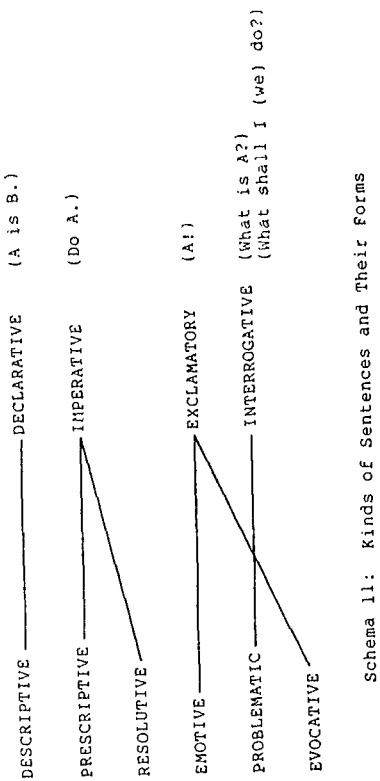
The following emotive conjugation of Betrand Russell adapted to an educational context is a good example of the force of words to elicit feeling:

> 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 netural 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 11 sets forth



Schema 11: Kinds of Sentences and Their Forms

the sentence forms for the various kinds of sentences: declarative for descriptive, imperative for prescriptive and resolutive, exclamatory for emotive and evocative, and interrogative for problematic. The declarative form, therefore, is the form of theoretical sentences.

But not all declarative sentences are theoretical, for the description must be of the universal and not of the unique; it must be quantitative and not qualitative. Qualitative description utilizes figurative not literal language, for figurative language permits the description of an unique. To describe the unique is to present the embodied meaning which is the 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 through the Mind, and rolls its rapid waves,
> Now dark--now glittering--now reflecting gloom--
> Now lending splendour, where from secret springs
> The source of human thought 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 raves.

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 enough meaning for meaning which is the whole, the one, the unique.

On the other hand quantitative 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 two somethings is given by making one a subject and the other a predicate relative to the subject. In the proposition, teacher-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

$$(\forall x)(\forall y)(Fx \cdot Gy \supset Rxy)$$

where 'Fx' 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, $\forall$, 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' in 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 ones. Observable terms are 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 the 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 is a symbol, x, which can take on one of a 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 with variables.

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 at all to 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 and are taken by some not to be theoretical terms. The difficulty with this usage of 'variable' is clear from what has been stated above. To call only some theoretical terms 'constructs' too has its difficulty, for all theoretical terms are constructs in the sense that they are developed through cognition.

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 engages in thought about the world, gives significance to the world, the experienced world cannot be an attribute of each personality. This is the subjectivist's position. There are not multiple realities, even though there are multiple perspectives. The objects experienced are to be distinguished from our cognition of them. The objects experienced enter into a common world which transcends cognition, though it includes cognition. Moreover, not all perspectives should be honored. Not all cognition is knowing; not all signs of the world, giving significance to the world, are adequate. This is the intersubjectivist'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

uniiversal 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 theoretical 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 concordance", "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 the 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

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 (the extension or reference of the term) and connotes the characteristics that a particular must have in order for the term to be applicable to it (the intension 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 definiendum--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:

$$\text{definiendum} =_{Df} \text{definiens}$$

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 definiendum 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.

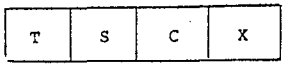
Because essential characteristics are differences which sort out one class from another class (differentia specifica) within a universe (genus proximum), definientia are logical products of classes (genus et differentia). Teacher is a logical product of the class of actors whose aim is guiding and the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

To order definitions into a chain, the definitions are arranged so that definientia are 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 definiens becoming the definiendum of the next definition, and so on until the chain is completed. Of course, the last link remains

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 $=_{Df}$ system consisting of subsystems of teacher (T), student (S), content (C), and context (X)



Schema 12: Subsystems of Education

1.1. System $=_{Df}$ complex of components in mutual interaction

1.2. Subsystem $=_{Df}$ system within a system

1.3. Teacher $=_{Df}$ actor whose aim is guiding learning of another

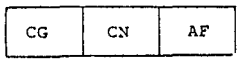
1.4. Student $=_{Df}$ actor whose aim is his or hers guided learning

1.4.1. Learning $=_{Df}$ psychical development

1.4.1.1. Psychical development $=_{Df}$ formation of mental structures

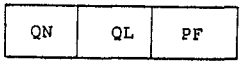
1.5. Content $=_{Df}$ structures for psychical development

1.5.1. Structures for psychical development $=_{Df}$ structures which are either cognitive (CG) or conative (CN) or affective (AF)



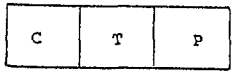
Schema 13: Psychical Structures

1.5.1.1. Cognitive structures $=_{Df}$ schemata for thought which are either quantitative (QN) or qualitative (QL) or performative (PF)



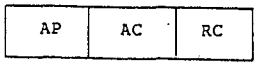
Schema 14: Cognitive Structures

1.5.1.1.1. Quantitative schemata for thought $=_{Df}$ propositions which are either criterial (C) or theoretical (T) or instantial (I)



Schema 15: Quantitative Schemata for Thought

1.5.1.1.2. Qualitative schemata for thought $=_{Df}$ propositions which are either appreciative (AP) or acquaintive (AC) or recognitive (RC)



Schema 16: Qualitative Schemata for Thought

1.5.1.1.3. Performative schemata for thought $=_{Df}$ patterns for either creative (CR) or

innovative (IN) or
conventional (CO) or
protocolic (PR) actions

CR	IN	CO	PR

Schema 17: Performative Schemata for Thought

1.5.1.2. Conative structures $=_{Df}$ schemata for volition

1.5.1.3. Affective structures $=_{Df}$ schemata for feeling

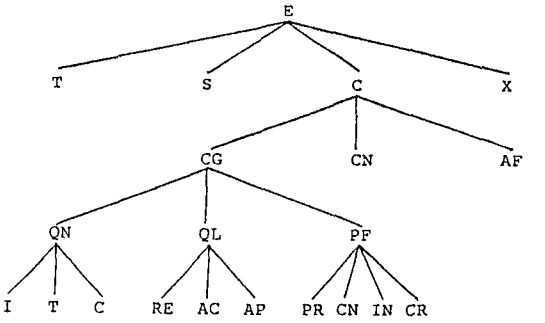
6. Context $=_{Df}$ position for learning

Because definitions are logical products of classes, as noted above, classification is basic to descriptive theorizing. However, not all descriptive theorizing is explicitly classification. Within the above definitional chain is some explicit classification.

A classification is a division of the phenomena which are the objects of theorizing. The objects of theorizing may be called 'the universe of the theorizing'. Schema 12 represents the partitioning of the universe, education (E), into four classes: teacher (T), student (S), content (C), and context (X). Since the universe is a set, called 'the universal set', its subdivisions, the classes are subsets. Thus, the classification can be symbolization in set theoretic notation as follows:

$$E = T \cup S \cup C \cup X$$

Classifications, however, are not always a simple partitioning of a universe. Classifications can be partitionings within partitionings. Schema 13 appears to be a simple partitioning of psychical structures for development into cognitive, conative, and affective classes, but such structures are the content of education and so are partitions within one of the partitions of education. Schema 14 too appears to be a simple partitioning, i.e., a partitioning of cognitive structures into schemata for thought which are either quantitiative or qualitative or performative. Yet such schemata constitute only one division of content, cognitive structures, which in turn constitute only one division of education. Quantitative, qualitative, and performative schemata for thought are subsumed under cognitive structures which is subsumed under content which is subsumed under education. Also the complexity of the classifications presented in Schemata 15, 16, and 17 can be seen in Schema 18 which places these classifications, as well as those discussed above, in their proper dependent relationship.



Schema 18: Classifications in Interrelation

The classes, as shown in Schema 18, are hierarchically ordered, and so constitute a taxonomy.

But not all hierarchies are taxonomies. An example of a hierarchy which is not a taxonomy is Kohlberg's classification of moral learning into stages which are arranged from lowest to highest. Another example is the classification of qualitative cognitive structures. These classes are ordered so that it is necessary to have one before the other. Recognitive structures are necessary for acquaintive ones; one must grasp qualities before grasping their relations. Moreover, acquaintive structures are necessary for appreciative ones; one must grasp relations before grasping interrelatedness or fitness. Prior necessity is not necessarily logical inclusion. In a taxonomic hierarchy, one class being less general is included in a more general one. Hence, given more than one kind of hierarchy, more precision

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 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--1 is less than 4--is included in a T of rank 2--1 + 1: I, T, and C in QN; RE, 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 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 philosophical theory, 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 hominological theory. Then I crossed over these two

partitionings and 18 classes could have been obtained. However, 6 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. Examples 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 for 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 not to confuse description or classification with descriptive theory or classificatory theory. Because of such theory one can categorize particulars and so 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 ones. Given the theory is only description of the properties of a system, 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 explication 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 (resultants) 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 resultant 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 resultants and those that set forth contingent relations between the determinants and the resultants. 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 resultants, these are relations that are essential and so arise from the very nature of the determinants and resultants. These relations have to hold or the determinants and resultants 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 of education follows. Autonomy and liberal content would have to be otherwise not to have this relation hold.

Contingent relations between determinants and resultants, on the other hand, are accidental and so do not arise from the very nature of the determinants and resultants. These relations do not have to hold for the determinants and resultants 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 skill achievement and 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 stamina and memory. Thus, the relation between skill achievement and intermittent practice could be otherwise without skill achievement and intermittent practice being otherwise. The very nature of skill achievement and intermittent practice does not demand that they be so related.

Both scientific and praxiological theoretical sentences express contingent relations. The difference between the two kinds is not with respect to form but with respect to content. As noted earler, 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 cohesiveness produces group influence on its members.

The effect of group cohesiveness on group influence of its members is described. Group cohesiveness is the determinant of the resultant, group influence of its members.

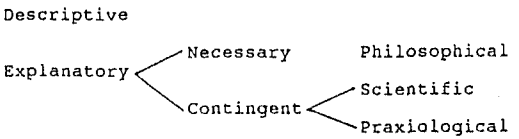
Praxiological theoretical sentences express accidental relations between properties so that the effectiveness of one or more properties in effecting one or more other properties is described. Stated differently, the sentences express universal generalizations about instrumental value, i.e., what means 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.

The effectiveness of the advance introduction of relevant subsuming concepts in effecting the retention of unfamiliar but meaningful verbal materials is described. Such organizers do facilitate and so are effective.

Schema 19 summarizes the kinds of theoretical sentences.



Schema 19: Kinds of Theoretical Sentences

It should be noted that there are also formal theoretical sentences which are necessary ones. However, they are not entered in Schema 19, since only necessary ones that fall under the category of explanatory theoretical sentences are included. Formal theoretical sentences are not explanatory of phenomena, because they are without content and so cannot function as universal generalizations that describe phenomena.

Even though there are different kinds of explanatory theoretical sentences, nevertheless they are all deterministic. However, some question whether theoretical sentences that explain human phenomena can be deterministic. Questioning is on the assumption that holding that all explanatory theoretical sentences are deterministic entails taking the position of a kind of determinism that is antithetical to free will. Free will is taken to be central to human being in the world. It is granted that if one holds that explanatory theoretical sentences are deterministic then it follows that one embraces determinism. Obviously, if one is a determinist, one holds that for whatever happens there are conditions so that, if obtaining, nothing else could happen. Theoretical sentences being deterministic in form express invariable connections which establish the controlling conditions. However, it is not granted that such determinism is antithetical to free will. The controlling conditions include in human phenomena, human decisions. Free will or self-determinism is not ruled out. In fact, if one did not take the position of determinism,

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 metaphysical 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 determination. What is involved is 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

$$D \rightarrow R$$

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 resultants. Also to be considered is the truth value of determinants and of resultants. In all the examples of theoretical sentences given above, the determinants and the resultants were simple and of positive 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 and one or more resultants related either as conjuncts or disjuncts. The following schema,

$$D_1 \wedge D_2 \rightarrow R_1 \vee R_2$$

where '$\wedge$' stands for and
'$\vee$' stands for either . . . or

is complex insofar as it has two determinants that are conjuncts and two resultants that are disjuncts. To be a con-

junct is to be part of a compounded property. All of the conjuncts are required in the determination. Both D_1 and D_2 are needed as determinants. To be a disjunct is to be an alternate. Any one or combination of the disjuncts can enter into the determination. R_1 can be the resultant or R_2 can be the resultant or both R_1 and R_2 can be resultants.

Turning to negative truth value, the theoretical sentence,

> Without student believing there is no student knowing

can be symbolized as

$$\sim D \rightarrow \sim R$$

where '$\sim$' stands for not
'D' stands for student believing
'R' stands for student knowing

In this theoretical sentence, no assertion is made that student 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 sufficient 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 according to time and according to certainty.

The schema for modification according to time is

$$D_t \rightarrow R_t$$

where 't' stands for time

It should be noted that explanatory theoretical sentences without a time modification do not present invariant sequences. The determinant is not taken as prior in time to the resultant. '$\rightarrow$' 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 to be represented like a machine. A machine is an object that consists of parts that act in predetermined ways to bring about certain specific effects. Thus, in such an object 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 combination 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 organismic 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 and so fixed actions. Rather parts act interdependently to maintain function, and thereby wholeness. The parts do not simply combine and then determine what the whole is to be. The content and form of 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 a mechanistic point of view; she or he could have an organismic point of view. To be a positivist what she or he needs to do is to reject theoretical sentences as candidates for knowledge unless they are a posteriori. That is to say, the positivist rejects theoretical sentences as candidates for knowledge unless they can be related to sensory data. She or he takes all other theoretical sentences as nonsense insofar as they are non-sensible. For her or him, only science and praxiology constitute knowledge; philosophy does not count as knowledge. If the positivist is a contemporary one, a logical positivist or logical empiricist, then she or he also accepts a priori analytic theoretical sentences as candidates for formal knowledge; she or he accepts logic and mathematics as knowledge. From my earlier discussion of kinds of knowledge, clearly I am not a positivist.

The schema for modification according to certainty is

$$D \rightarrow \mathcal{O}R$$

where '$\mathcal{O}$' stands for probably

Often theoretical sentences in the hominological 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 of the calculus, C, that 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 language, L, such that some permissible or well-formed formulations, wffs, of L are underived (are postulates, P's) with respect to rules of transformation, G^T, and from which by application of G^T, theorems (T's) are derivable.

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

One subset of the transformation rules (G^T's) is constituted by replacement rules (definitions, D) establishing synonymies. This is a metatheoretical view of definitions. The theoretical view is that definitions constitute descriptive metaphysics. That is to say, on the theoretical level, a definition describes properties of the phenomena; while on the metatheoretical level, the definiendum is an abbreviation for the definens. The descriptive definition becomes an abbreviatory one which states a rule for substituting fewer terms for more terms. Rules are stipulations (demands for agreement) which are conventions (agreements). Thus, any definition can be viewed as stipulative and conventional. 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^{SY}, which are rules for form, and semantical rules ,G^{SE}, 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 G^{SE}. We have already noted one subset of G^{SY}, the transformation rules, G^T, which include the replacement rules, D. The other subset of G^{SY} is the formation rules, G^F. These rules determine the well-formed formulations of the language, 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:

P1: $A \rightarrow B$

P2: $B \rightarrow C$

P3: $D \leftrightarrow C$

Some of the theorems would be:

T1: $B \rightarrow D$

T2: $A \rightarrow C$

T3: $A \rightarrow D$

T1 can be derived from P2 and P3:

*1.	$B \rightarrow C \cdot D \rightarrow C$	P2, P3
*2.	$B \rightarrow D$	(1) TF
3.	$B \rightarrow C \cdot D \rightarrow C \supset B \rightarrow D$	*

T2 can be derived from P1 and P2:

*1.	$A \rightarrow B \cdot B \rightarrow C$	P1, P2
*2.	$A \rightarrow C$	(1) TF

$$3.\ A \rightarrow B \cdot B \rightarrow C . \supset A \rightarrow C \quad *$$

T3 can be derived from P1 and T1:

$$*1.\ A \rightarrow B \cdot B \rightarrow D \qquad P1,\ T1$$

$$*2.\ A \rightarrow D \qquad (1)\ TF$$

$$3.\ A \rightarrow B \cdot B \rightarrow D . \supset A \rightarrow D \quad *$$

In the above deductions 'TF' stands for truth functional rules set forth in Truth Functional Syntactics in Appendix I. Truth functional rules are transformation rules, G^{*}. The particular rule being applied here is

$$p \supset q \cdot q \supset r . \supset p \supset r$$

Zetterberg in ON THEORY AND VERIFICATION IN SOCIOLOGY sets forth a deductive relating 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

$$I.\ A \rightarrow B$$

$$II.\ B \rightarrow C$$

$$III.\ D \rightarrow C$$

He then uses Postulates II and III to derive 3, $B \rightarrow D$, and so orders it under the postulates as a theorem in the system. He then goes on to derive $A \rightarrow C$, using Postulates I and II, and $A \rightarrow D$, using Postulate I and the first theorem he derived, $B \rightarrow D$. (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.

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-studenting context.

When the explanatory theoretical sentences can be presented as a fully articulated deductive system, then the theory can be said to be made fully formal. However, such full formalization is rarely, if ever, possible in theorizing about human phenomena. The impossibility arises from another impossibility which is that of not suppressing exogenous material.

Material that is suppressed--postulates or theorems or vocabulary (definitions)--is either indigenous (within the theory) or exogenous (without the theory). The indigenous material can be suppressed premises or implicit presupposition of vocabulary. The exogenous material is implicit presupposition of large segments of theory of other disciplines (e.g., presupposed psychological theory within educational theory). While suppressed premises can be stated and definitions and undefined vocabulary explicitly stated, it is not possible to make explicit all of the presupposed theories of other disciplines in theory about human phenomena which incorporates theory from so many disciplines. Thus, one settles for partial formalization.

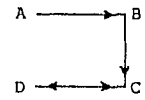
Digraphing is an alternative to deductive ordering of explanatory theoretical sentences. Digraphing is an ordering of theoretical sentences in which the determinants and resultants are interpreted as points and the connections between them as lines directed from determinant to resultant. For example, given the same explanatory theoretical sentences that Zetterberg set forth as the three postulates in his deductive system,

$$A \rightarrow B$$

$$B \rightarrow C$$

$$D \rightarrow C$$

they can be ordered through digraphing and the order either presented diagrammatically



or in a matrix

	A	B	C	D
A	0	1	1	1
B	0	0	1	1
C	0	0	0	1
D	0	0	1	0

or as relations

(A,B), (A,C), (A,D)
(B,C), (B,D)
(C,D)
(D,C)

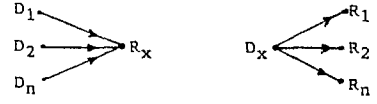
Through the ordering by digraph, the theoretical explanatory sentences, the theorems stated by Zetterberg, also emerge:

$$A \rightarrow C$$

$$A \rightarrow D$$

$$B \rightarrow D$$

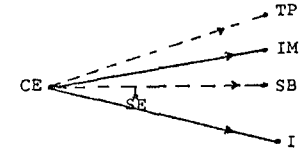
Inventories of determinants (D) of given resultants (R) and inventories of resultants of given determinants would be special cases of digraphing in which there is no chaining. These cases are represented below.



Schema 20: Inventories

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 in 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.



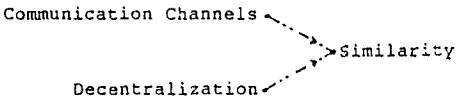
Schema 21: Inventory of CE's Resultants

From the examples of the digraphs, it is clear that digraphs can 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 resultant which consists of disjuncts, then the digraph would have to be

represented differently, for one or any combination of the disjuncts could produce the effect. Mullins in THE ART OF THEORY presents such a digraph from Berelson and Steiner's Theory of Organization.



Schema 22: A Digraph Which Represents Disjuncts

To summarize this section on explicating the explanatory 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.

4. EVALUATING THEORY

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

'Criticism' comes from the Greek '_krinein_' meaning to separate out or to select. The essence of the act of criticism 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 considered. Is the worth intrinsic or instrumental? If it is intrinsic worth, is it either epistemic or moral or aesthetic 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.

Since the function of theory is to present knowledge of universals, the worth considered here will be epistemic. Theories are selected on the basis of truth. Aquinas presented a succinct definition of truth: "_Veritas est adaequatio rei et intellectus_." (_De Veritate_, Q. 1, A. 1) Although the literal translation of the Latin is "Truth is the adequation of things and the intellect", perhaps it is best 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, and of what is not that it is not, 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 Phlogiston Theory was accepted. Today we know that oxygen not phlogiston--a supposed volatile constitutent of all combustible substances--is involved in burning. Another example that predated Copernicus (1473 - 1543) would be the Ptolemaic 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. Consider the disagreement between Reich and Freud about the nature of the unconscious. Reich claimed that what Freud presented as the unconscious--the basic sexual and aggressive nature of the human being--was not primary but secondary, a deformation of a basic social and non-aggressive human nature. 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 advancement in human knowledge.

Human fallibility, thus, results in emergent truth for human beings. In other words, the human being does not possess 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 it: If belief "were to tend indefinitely toward absolute fixity," 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 Belief", in which he introduced the word 'inquiry' to signify 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, however, that most persons employ not the method of inquiry but that of tenacity or authority or "agreeableness 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 shutting out from all influences so as to remain settled in a belief. Fiat is the essence of the method of authority; the test is what the leader thinks. Preference is the basis of agreeableness to reason or what Peirce called 'the a priori method'; what the reason inclines to the reason claims.

Peirce used 'scientific' for 'rational', but 'scientific' was used by him in its earlier sense. As already discussed, in its earlier sense 'science' encompasses all of theoretical knowledge including philosophy. Therefore, it would be a mistake to narrow the method of inquiry to that which is productive of science 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 method is a part of the inquiry method. It is a part of and not, as the 17th. Century Rationalists (Descartes, Spinoza, and Leibnitz) thought, all of being rational.

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 reasons why a theory is true or false, the explication must be in the context of epistemic criticism. To be in such a context is to be an unfolding 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 syntactics. 'Pragmatics' comes from the Greek 'prattein' to do, and so pragmatics treats of 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 of the relation of language to language user in so far as it treats of functions of language, it does not treat of purposes of the language user except as the language user's

purposes coincide with functions of language. Furthermore, functions of language are determined through analysis of the language in use and not through the behavior of one using the language already in use. This analytic sense of 'pragmatics,' when I first set it forth in the sixties, was called by me 'analytical pragmatics' to distinguish it from C. W. Morris; behavioral pragmatics (1955).

While it is true that human beings develop language to serve their purposes, human beings cannot make what has been developed for certain purposes function for other purposes. Perhaps an analogy would be helpful. Human beings invented the synthetic fabric, nylon. But nylon can do only what its structure (its form and content) permit. It cannot function as human food even though a human user erroneously could set forth such a purpose for it. The functions of nylon follow from an analysis of its structure.

'Semantics' comes from the Greek 'sema' sign, and so semantics treats of the meaning of the language, its content. Finally, 'syntactics' comes from the Greek suntassein to put together, and so syntactics treats of the arrangement of the language, its form. Therefore, to explicate language is to present its order through its function, content, and form.

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 its usual narrow sense wherein reference is only made to form, to syntactics.

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 conclusion or conclusions follow from the premise 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

> 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. $p \supset q$

*2. $r \supset p$

*3. $\bar{q} \supset \bar{p}$ (1) Trans.

*4. $\bar{p} \supset \bar{r}$ (2) Trans.

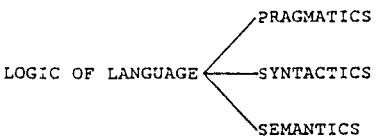
*5. $\bar{q} \supset \bar{r}$ (3) (4) H.S.

*6. $r \supset q$ (5) Trans

7. $p \supset q \quad r \supset p \therefore r \supset q$ •

where 'p' stands for the frequency of teacher-student interaction increases
'q' stands for teacher-student liking increases
'r' stands for teacher-student ratio decreases
'Trans.' stands for the rule of transposition, i.e., $p \supset q \therefore q \supset p$
'H.S.' stands for the rule of hypothetical syllogism, i.e., $p \supset q \quad q \supset r \therefore p \supset r$

'Logic' in a broader sense addresses itself also to the pragmatical and semantical aspects of language. Logic of language, consequently, consists of pragmatics and semantics as well as syntactics. See Schema 23.



Schema 23: Components of the Logic of Language

Since adequate theoretical language functions to pres-

ent knowledge of universals, such language will present reality and thus be true or have epistemic worth. In order to so function, theory must meet 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 thus is checking the theory against the appropriate syntactic and semantic criteria. The remainder of this section on evaluating theory will present these criteria.

In explicating theory, it was discovered that when one sets forth 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 bearer of the property and so 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) and connotes the characteristics that a particular must have in order for the term to be applicable to it (the intension of the term). Since extension is determined by intension and a definition sets forth the intension of a term, definition is basic to classification.

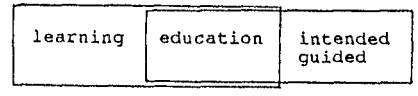
What then are the criteria for a classification which is of epistemic worth? The criteria are exactness, exclusivity, exhaustiveness, external coherence, and extendability.

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

or essential characteristics (differentia) 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 genus and intended guided as the differentia. This definition can be presented through Schema 24.



Schema 24: Definition of Education

To determine whether the above definition of 'education' meets the exactness criterion one can use the method of imaginative 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., $S_i \cap S_j = \emptyset$ for every pair of subclasses under consideration.
>
> Exhaustiveness: Every element in the given universe should be in some subclass, i.e., $\cup S_i = u$, where 'S_i' stands for 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_i.

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 education--intended and guided--(E). Schema 25 represents this classification.

F	T	D	E

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_i.

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. 'Knowledge', as he defines it, "involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting" (1964, p. 186). For him, "the abilities and skills objectives 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 of cognitive psychical development that are not classified. Bloom does not include, for example, qualitative cognition. Knowledge of particulars (specifics) and knowledge of generals are included but knowledge of uniques is excluded.

Bloom, moreover, calls his classification, "a taxonomy". In his classification, the classes are ordered as follows. The universe of cognition is subdivided into two classes, KNOWLEDGE and INTELLECTUAL ABILITIES AND SKILLS. Then KNOWLEDGE is subdivided into three subclasses: KNOWLEDGE OF SPECIFICS, KNOWLEDGE OF WAYS AND MEANS OF DEALING WITH SPECIFICS, and KNOWLEDGE OF THE UNIVERSALS AND ABSTRACTIONS IN A FIELD. Then KNOWLEDGE OF SPECIFICS is subdivided once again into two classes; KNOWLEDGE OF WAYS 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 numbers of subdivisions are involved. INTELLECTUAL ABILITIES AND SKILLS is subdivided into six classes, and all but one of these subclasses are also subdivided. COMPREHENSION is subdivided into three classes; ANALYSIS into three classes; 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 but 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_{ij} where the subscript j indicates the particular level for the taxon or its rank. The subscript i is arbitrarily assigned to differentiate the taxa at 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 k such that T_{ij} is included in T_{km} for $m = j + 1$.

3. The number of taxa of rank j is greater than

the number of taxa of rank j + 1.

4. Taxa of each rank are mutually exclusive and exhaustive. Stated more precisely, for a given rank j, $T_{ij} \cap T_{kj} = \emptyset$ for any i and k appearing as subscripts in the taxa of rank j, and $\bigcup_i T = u$.

Bloom's classification meets at least the first three conditions. The lowest level of his classification is 1 and the highest level is 3. The taxa in level 3, T_{13} (KNOWLEDGE) and T_{23} (INTELLECTUAL ABILITIES AND SKILLS), are differentiated symbolically by their first subscript, while their second subscript indicates that they are both taxa of level 3. Moreover, every taxa of rank 1 is contained in a taxon of rank 2 and every taxa of rank 2 is contained in a taxon of rank 3. 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 <u>external coherence</u> 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. Two statements are related by logical implication when one statement, S", is a logical consequence of the other, S'. To be a logical consequence means, of course, S" logically follows from S'. This can be checked out 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 truth value interpretations). If and only if the conditional is valid, is there 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 conditional can come out false. But it came out true under all cases. So S" must logically follow from S', for S' is true 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 were 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 acting where the body was involved. This division, however, does not fit in with extant theoretical knowledge. This knowledge is found in philosophical psychology, and some was developed long ago by Plato.

Plato, in THE REPUBLIC and elsewhere is his writings, set 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 by 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 relate in human action, the body-mind problem, 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. Wherever there is 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 communicating it in writing. So educational objectives for developing structures for handwriting fall into the same domain of educational objectives as do those for developing structures to solve 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 psychical development then either cognitive or conative or affective, and if educational objective then psychical development.

That is the schema

$$p \cdot \neg q \vee r \vee s : t \neg p : \neg t \cdot \neg q \vee s \vee u$$

where 'p' stands for psychical development
'q' stands for cognitive
'r' stands for conative
's' stands for affective
't' stands for educational objective
'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 extendability 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 albeit 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 extendability--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:

definiendum $=_{Df}$ definiens

where 'definiendum' stands for the term to be defined
'definiens' stands for the defining term
'$=_{Df}$' stands for logical equivalence between the definiendum and the definiens

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 (Ds) 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 psychical development was stated as a rule of replacement in the section on explicating theory.

Learning $=_{Df}$ psychical development

This can be stated also as

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

Psychical 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 necessary relation between the word selected to refer to learning and learning. The relation is stipulated by the developers 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 advan-

cement of knowledge, there must be adherence to the criterion of external coherence.

The criterion of chaining is as follows:

> the definitions can be explicated so that the 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 deducible 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.

D1. $Rxy =_{Df} Syx$

D2. $Txy =_{Df} Fx \cdot Rxy$

D3. $Uxy =_{Df} Rxy \cdot \sim Txy$

D4. $Vxy =_{Df} (\exists z)(Rxz \cdot Rzy)$

D5. $Wxy =_{Df} \sim Fx \cdot Vxy$

where the universe of discourse is persons
'R' stands for parent
'S' stands for child
'T' stands for father
'F' stands for male
'U' stands for mother
'V' stands for grandparent
'W' stands for grandmother

Each defined term can be eliminated in favor of primitive terms through a definition chain. For example, the expression

$$Wxy$$

can be eliminated in favor of

$$\sim Fx \cdot (\exists z)(Szx \cdot Syz)$$

which contains only primitive terms.

1. $Wxy =_{Df} \sim Fx \cdot Vxy$
2. $Wxy =_{Df} \sim Fx \cdot (\exists z)(Rxz \cdot Rzy)$ D4
3. $Wxy =_{Df} \sim Fx \cdot (\exists z)(Szx \cdot Syz)$ D1

The theoretician when she or he attends to definitions qua definitions--definitions as rules of replacement--is on the metatheoretical level not the theoretical level. The focus is discourse about education not education. Perhaps that is one reason for Rudner labeling classifications 'non-theoretic'. But I would argue that on the theoretical level they are descriptive. It is only on the metatheoretical level that they can be viewed as not part of theory; on this level they are but rules governing replacements within theory.

To summarize this section on evaluating descriptive theory:

> a descriptive theory is true if and only if it meets the following criteria:
>
> semantic: exactness
>
> exclusivity

exhaustiveness

external coherence

extendability

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--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 sense and content proper to the concept of any phenomena whatever, and hence proper to the concepts whereby the empirical psychologist expresses the psychical 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 entrenched

within a descriptive metaphysics that meets the criteria for truth. Thus, the first criterion for the adequacy of explanatory theory emerges: well-defined terms.

As was seen in the explication of explanatory theory, the sentences constituting the theory express invariable relations between the properties so that some properties are controlling conditions for other properties. The properties that are controlling conditions are called 'determinants' and the properties of which they are controlling conditions are called 'resultants'. Theoretical explanatory sentences, therefore, to be such must take a deterministic form. The form of such sentences can be set forth in the following schema:

$$D \rightarrow R$$

where 'D' stands for the determinant
'R' stands for the resultant
'→' stands for a relation in which D is the controlling condition of R

Of course, as also seen in the explication of explanatory theory, this basic schema can be modified by

1. introducing symmetry, making the resultant also a controlling condition of the determinant,

2. modifying the determinant or resultant as to truth value, making the absence or the presence of the property a determinant or a resultant, and

3. increasing the number of determinants or resultants, making the determinant or resultant complex.

From the above discussion, the second criterion of adequacy of explanatory theory emerges, i.e., determinancy. The sentences of theoretical explanatory theory must be deterministic in form.

The theoretical explanatory sentences to be true must not only have the correct form, meet the syntactic criterion of determinancy, but must also have a content which corresponds to reality. With respect to the correspondence to reality, theoretical sentences which express necessary rela-

tions (philosophical theoretical sentences) must be considered separately from those which express contingent relations (scientific and praxiological theoretical sentences). Since necessary relations between the determinants and resultants are those that are essential and so arise from the very nature of the determinants and resultants, given the nature of the determinants and resultants 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. $q \supset r$

*2. $r \supset s$

*3. $q \supset s$ (1) (2) TF

4. $q \supset r \cdot r \supset s . \supset q \supset s$ *

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. $q \supset s$

*2. $p \supset q$

*3. $p \supset s$ (1) (2) TF

4. $q \supset s \cdot p \supset q . \supset p \supset s$ *

Since to have liberal content of education (t) 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. $t \equiv s$

*2. $p \supset s$

*3. $p \supset t$ (1) (2) TF

4. $t \equiv s \cdot p \supset s . \supset p \supset t$ *

Of course, the establishment of the necessary relation ultimately depends upon whether the determinant and resultant are well-defined. The essence of autonomy is taken to be a decision-maker. The essence of the content of liberal education is taken to be knowledge. That these are adequate definitions is established by the phenomenological 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 no 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 connections 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 to instances. This is so because the variable is 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 then properties can be connected to them. And 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 human experience, but 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 knowing 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 averages. The values are obtained by assigning weights of 4, 3, 2, 1, and 0 to grades of A, B, C, D, and F respectively. The grades are obtained by 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 well-defined, one does not have 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 descriptive metaphysics. 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 Zetterberg 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 definition is 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 Zetterberg does.

> One may here question the place of operationalism in sociology. A very legitimate aspect of operationalism concerns the definitions of score values on variable. When we are asked, not <u>what variable</u> a certain scale measures, but <u>what value</u> 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--in short, an operational definition. (p. 113)

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

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. These properties fit into a network of relations between properties, some of which can be directly related to data. For example, in Freud's theory, compulsiveness is a property that is observable and so can be associated with a variable, while an unconscious desire is not. But the unconscious desire can be related to repression which in turn can be related to compulsive behavior. Such interrelation of properties depends upon a systematization of the theoretical sentences.

If one accepts operationalism, then all properties that are not directly associated with variables would be meaning-

less. A behaviorism that holds that psychology is not the study of mental events but of behavior is a form of operationalism. But such a position would not make possible completeness in psychological theory. So behaviorism has been modified among most psychologists so that the variables are associated with behavioral properties and other non-behavioral properties touch down in data through the behavioral properties. Operationalism, as a viable philosophy of science, is extinct even in physics where it began with P. W. Bridgman, the Nobel prize-winning physicist.

The deficiency of operationalism with respect to completeness has brought forth yet another semantic criterion. Explanatory theory, whether it be philosophical or scientific or praxiological, must set forth all the relations between all the properties within the domain of theorizing. Explanatory theory must meet the criterion of completeness.

Since the content of theory goes beyond sentences to their interrelation, a criterion relative to the systematic nature of theory also must be attended to. This criterion is coherence. 'Coherence' comes from the Latin 'cohaerere' meaning to cling to. Theory is systematic insofar as 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 applied, however, unless the sentences of the theory 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, are deducible.

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 theorems. The necessity resides both in the connection of the axioms and the theorems and in the very positing of the axioms. There are no qualifications with respect to truth; there is no supposing; hence the term 'categorical'. A famous example is Spinoza's system of ethics presented in his ETHICA ORDINE GEOMETIC DEMONSTATA (1677).

Theoretical systems which describe necessary relations

within reality are philosophical. However, it should be noted that Spinoza, and most thinkers before him following Aristotle's lead, took the presentation of theory in categorical axiomatic form to be the proper form for all knowledge about reality. Aristotle put it this way: ". . . it is necessary that scientific demonstration start from premisses which are true, primitive, immediate and more evident than the conclusions, being prior to them as their cause" (POSTERIOR ANALYTIC, I, 2). The term 'scientific' should not be construed other than in the general sense of knowledge. Given such a construction, it not contradictory to speak of a science of metaphysics.

In the hypothetical axiomatic system, no certitude resides in the axioms; there is no self-evidency. Thus, it would be better to use the term 'postulates' rather than 'axioms'. This judgment is based upon Euclid's distinction between postulates and common notions (later termed 'axioms') in which common notions are taken to be self-evident. Two kinds of hypothetical axiomatic systems may be distinguished: the formal and the material.

In the formal hypothetical axiomatic system, the terms have no meaning apart from the relations among them. Thus, there is no attempt to advance evidence, but only to link premisses to conclusions. Logic and mathematics are formal hypothetical axiomatic systems.

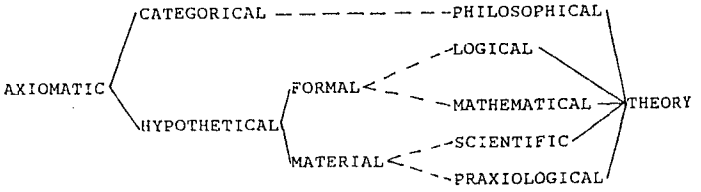
The formal nature of logic and mathematics became apparent with the working out of non-Euclidean geometries in the nineteenth century. In this regard, the geometry of Lobatchevsky and that of Riemann immediately come to mind. A major importance of seeing logic and mathematics as abstract structures resides in their use in constructing theory about reality. Theory that is about reality is material theory. Abstract structures being systems of relations can give form to different systems of content; they can be used as models for constructing theory. Formal theory models will be discussed further in the next section on theory construction.

In the material hypothetical axiomatic system, truth is conferred upon the postulates through the truth of theorems related to the postulates as their consequences. The postulates are hypotheses to be checked out in terms of the consequences which can be deduced from them. Classic examples of such systems are Fourier's thermodynamics set forth in THEORIE ANALYTIQUE DE LA CHALEUR (1882) and J. C. Maxwell's electromagnetic theory set forth in TREATISE ON ELECTRICITY

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 system is 'hypothetico-deductive system'. That is why in the literature, one finds reference to science as hypothetico-deductive in nature.

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



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 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. Homans set 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'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-three theorems. He checks 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 3. 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

*1.	$p \supset qr$	P3
*2.	$p \supset q$	(1) TF
3.	$p \supset qr .\supset p \supset q$	*

where 'p' stands for the Other's activity is

valuable to Person
'q' stands for the Other's activity rewards the Person
'r' stands for the Person's activity rewards the Other

To illustrate an inadequate check, Maris erroneously deduces what he calls 'Theorem 3' from Postulate 2. Theorem 3 is

> As the expectation goes unrealized and his activity goes unrewarded by Other, Person emits the activity less and less often.

The deduction is

*1. $p \supset q$ P2

*2. $\sim p \supset \sim q$ (1) E.A.

*3. $\sim q \supset \sim p$ (2) Conversion

4. $p \supset q \ .\supset \sim q \supset \sim p$ *

where 'p' stands for the more within a given period of time a man's activity rewards the activity of any Other
'q' stands for the more within a given period of time the other will emit the activity
' p' stands for the less within a given period of time a man's activity rewards the activity of any Other
' q' stands for the less within a given period of time the other will emit the activity
'E.A.' stands for empirical association
'Conversion' stands for an invalid truth functional schema, namely,
$\sim p \supset \sim q \ . \equiv \sim q \supset \sim p$

The deduction is erroneous for three reasons. The first reason is that p is not a negation of p 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 refer to empirical distributions, 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

*1. $p \equiv q$ P2

*2. $q \supset p$ (1) TF

3. $p \supset q \ .\supset q \supset p$ *

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 obtains. 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 correspondence 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 obtain. The theory must be logicially consistent with extant knowledge. The exogeneous 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 connectedness 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:

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

where 'D' stands for density
'DC' stands for number of direct connections
'N' stands for number of properties

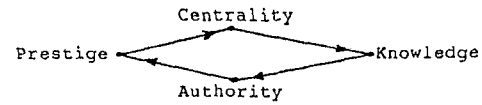
Obviously, less than N-1 direct connections results in some properties not being connected. Thus, density cannot fall below some minimum value.

Connectedness is the number of direct and indirect connections over the number of possible connections. Therefore, connectedness is given by the following equation:

$$C = \frac{DC + IC}{N(N-1)}$$

where 'IC' stand for number of indirect connections

To illustrate, consider the digraph which sets forth Hopkins' ordering of theoretical generalizations about influence in small groups as presented in Zetterberg (p.92).



Schema 27: Diagraph Ordering Generalizations about Influence in Small Groups

This digraph has four direct connections (DC = 4) with a possibility of twelve connections (N = 4 and so N(N-1) = 12). The density then is .33 which is not below the minimum. All the properties are connected. Moreover, there are eight indirect connections (IC = 8). The connectedness then is 1. All the properties are completely connected. There are no missing connections.

To summarize this section on evaluating explanatory theory:

> an explanatory theory is true if and only if it meets the following criteria:
>
> semantic: well-defined terms
>
> correspondence with either necessary or contingent relations
>
> coherence with other explanatory theory
>
> completeness
>
> syntactic: determinancy
>
> internal coherence or logical consistency

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

Besides intuitive certainty through well-defined terms,

determinancy, correspondence, coherence, and completeness, there is one other attribute that is taken to be characteristic of worthwnile 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 injunction that entities should not be multiplied unnecessarily. That injunction has come to be known as Ockham's razor which theoreticians 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 concepts and the theoretical sentences to express the universal generalizations. Unless the theoretical sentences and the predicates are systematized, it is difficult to determine redundancy. In a well-wrought system, there are no unnecessary entities. The theoretician that formalizes wields Ockham'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 contain 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′ is more adequate than T"

if and only if

1. T′ is more functional than T"
   or
2. T′ and T" are both functional but T′ 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 objective of theorizing. The theory is functioning as it should. That is to say,

T′ is more functional than T"

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′ is more comprehensive than T"

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 syntactically 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 theory unless one comes to understand present theory and what, if anything, needs to be done to make the theory adequate. One comes to understand theory through a detailed account of it, i.e., through an explication in which its content and form are set forth. One comes to understand what, if anything needs to be done, through judgment of it, i.e., evaluation in terms of standards for its content, semantic criteria, and for its form, syntactic criteria. If anything needs to be done to the theory, it 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, retroductive, deductive, and inductive. Of these four forms of reasoning, only one does not enter into theory construction. Induction does not so enter. However, induction does enter into theory building for it is one form of reasoning involved in critiquing theory.

Induction enters into critiquing theory for it is the kind of reasoning involved in determining whether theory is supported by data. Since through empirical explanatory theory--scientific and praxiological theory--one proposes what the contingent relations between properties are, there must be a mode of reasoning for checking the proposals against data. The mode of reasoning is induction. Induction permits one to infer from some instances to all instances and so to utilize observations--data--to establish a correspondence between theory and data.

Peirce has set forth the essence of induction as follows:

> Induction may be defined as an argument which proceeds upon the assumption that all the members of a class or aggregate have all the characters which are common to all those members of this class concerning which it is known, whether they have these characters or not; or, in other words, which assumes that that is true of a number of instances taken from it at random. This might be called a statistical argument. (VALUES IN A UNIVERSE OF CHANCE, pp. 45-46)

Since in statistical argument the inference is from a number of instances to the whole collection of instances, the conclusion obviously makes claims that go beyond the premises. Thus, the conclusion is only probable not necessary. The form of the inductive inference makes this clear:

1. A is true of b_1, b_2, . . ., b_n; and
2. b_1, b_2, . . ., b_n are some members of class B;
3. hence, A is true of <u>all</u> members of class B.

Induction as statistical inference rules out spurious senses of induction. One spurious sense is that induction is a process of reasoning in which one derives theory from data. This sense arose 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. The one hurries on rapidly from the senses and particulars to the most general axioms; and from them as principles and their supposed undisputable truth derives and discovers the intermediate axioms. . . . The other constitutes its axioms from the senses and particulars, by ascending continually and gradually, till it finally arrives at 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 in the greatest generalities. 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 rises 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 researcher, according to Bacon, should focus on the particulars of the world. Then through abstraction from particulars, generalizations about the world can arise, i.e., induction can take place.

The naturalistic and objectivistic standpoint which is expressed in Bacon's thought is the source of this erroneous view of induction. A naturalistic standpoint takes whatever is as either physical or psychical, but the psychical is made dependent upon the physical--an accompaniment. Thus, whatever is, is one all encompassing system of nature. Everything is naturalized including consciousness. There is no essential alteration in this interpretation, when, in the Eighteenth Century empiristic sense, nature is broken up into complexes of sensations. Objectivism is a position that the being of the world is its existence and that whatever is merely subjective must be eliminated.

The naturalistic and objectivistic standpoint must be given up, for it eliminates consciousness, the subject, and so meaning. Empiricism is clearly bankrupt. Data cannot give sense. Meaning does not wait in the object to be discovered. Rather consciousness gives meaning, and so consciousness of the world is consciousness constituting the meaning of the world. Consciousness is a state of self-awareness; it is a condition for cognition, for it is an I that must believe. Consciousness, then, of objects is a state in which an I gives meaning to objects appearing as phenomena. Signification occurs. Signs set forth the meaning or the sense.

Peirce defined a sign as "something that stands to somebody for something in some respect or capacity" (COLLECTED PAPERS, 2.228). Peirce, furthermore, characterized three primary kinds of signs. First, there is the index which he states is "a sign which refers to the Object that it denotes by virtue of being really affected by that object" (2.248). An example would be a darkened sky as a sign of a storm to come. Second, there is the icon which he

states is "a sign which refers to the Object that it denotes merely by virtue of characters of its own" (2.247). An example would be a diagram as a sign of a space shuttle. Finally, there is the symbol which he states is "a sign which is constituted a sign merely or mainly by the fact that it is used or understood as such" (2.307). An example would be the term 'consciousness' used as a sign for a state of self-awareness.

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 significance to phenomena with respect to their universality 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 praxiology. 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 retroduction are the forms for devising theory. Intuition is a form of reasoning 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 stereotypically are considered as having intuitive powers, since their powers of insight are characterized as irrational in opposition to the intellectual powers of men which are taken as rational ones. Intuition, however, is a rational power, a form of reasoning albeit non-discursive; it is a non-inferential form of reasoning.

'Intuition' comes from the Latin verb, 'intueri' meaning to look upon; and intuition is a looking upon for it is an immediate apprehension by the intellect of the nature of objects given as phenomena. Intuition is a direct intellectual observation of the essence of what is given in experience. Experience 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, a method of thought set forth by Edmund Husserl (1859-1938). The term 'phenomenology' was introduced by Johann Heinrich Lambert in NEUES ORGANON (Leip-

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 das Ding an sich (things in themselves), things as they are in themselves independently of human signification. Consequently, the notion of a reality in itself or an absolute object is unthinkable as is a consciousness whose job is to perceive reality in the original. In the middle of the nineteenth century, the term 'phenomena' was restricted 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 so restrict descriptive study, everything that 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 phenomena is the necessary foundation of all true cognition. Every indirect acquisition of knowledge is a deduction or retroduction from some other knowledge. If knowledge is to be grounded, there must be direct knowledge upon which to base it. Such direct knowledge is obtained only through observation of the things themselves. This observation cannot be sensory but must be intellectual, since, as pointed out above, meaning does not reside in the things but is the constituting intentionality of consciousness.

Husserl in PHENOMENOLOGY AND THE CRISIS OF PHILOSOPHY (1936) pointed out that in the hominological disciplines the lack of grounded knowledge is most apparent. As long as psychologists and sociologists take a naturalistic and objectivistic standpoint, they cannot accomplish the analysis of consciousness which is necessary to give their constructs validity. Constructs cannot be given validity in terms of other constructs unless the other constructs are grounded in sense. Signification must be given to human phenomena. Sense or meaning must be generated in the form of descriptors which set forth properties. Valid descriptors are only possible through descriptive metaphysics which arises out of the phenomenological method whose leading rule is to turn to the objects themselves given as phenomena.

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 gaze only upon the object. In order to eliminate what is useful for the subject, the inquirer must ask not what purpose the object can serve but simply what the object is. In other words, the inquirer must take the contemplative standpoint. This rule is not new, for it has governed theoretical inquiry. It has long been recognized as an essential ingredient of the scientific method. Also it is the rule that insures what has been called 'objectivity' in inquiry. However, '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, affective and conative states always accompany cognitive states, and so it is impossible for an inquirer to be in a purely cognitive state. However, what this rule is calling for is an affective and conative state that is not extrinsic to the cognitive state of an inquirer. That is to say, the inquirer should desire and will knowledge for its own sake. Secondly, use could be studied from a contemplative standpoint, since instrumental value can be an object of theoretical inquiry.*

The third rule of the phenomenological method is to exclude everything known which is not directly given in the object under inquiry. The known not directly given can be by inference or from other sources. The known through inference must be excluded in order that what is deduced or retroduced can be grounded phenomenologically. Descriptive metaphysics is the grounding required for all deductions and retroductions. The same argument can be advanced for the known set forth in the literature. What is asserted by others must never be relied upon as a foundation. Knowledge must be grounded in descriptive metaphysics.

The fourth rule of the phenomenological method is also an exclusion rule. What should be excluded is the nonessential. Only what is essential to an object should be included. Thus, both existence and what is contingent 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 nonexistent and merely imagined. What is contingent should be excluded because it is inessential. To return to the above example, a Bachelor of Arts degree is inessential to a liberal education and so should be excluded.

The fourth rule of the phenomenological method is an important difference marking descriptive metaphysics off from science and praxiology. The descriptive metaphysician ignores existence, while the scientific or praxiological inquirer does not and 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 so be blind to certain elements that are given. The task of the phenomenologist thus is to strive for complete disclosure. The sixth rule is to be descriptive. Since objects are complex, they must be taken apart and the elements described. Heidegger, another German phenomenologist, calls this kind of analysis "exegesis" 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 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 retroduction, theory, 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 signification 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 a characteristic of an example. But one does not appeal to empirical observation nor does one simply regard a characteristic as essential. Instead with each characteristic, one asks whether without it the example could be considered an example of the same sort of thing as before. One asks what characteristics an object must have in order to be recognized as 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 studenting-teaching one in order to be education.

The other form of reasoning through which theory can be devised is retroduction. Peirce pointed out and named this form of reasoning.

> The inquiry begins with pondering these phenonmena in all their aspects, in the search of some point of view whence the wonder shall be resolved. At length a conjecture arises that furnishes a possible Explanation, by which I mean a syllogism exhibiting the surprising fact as necessarily consequent upon the circumstances of its occurrence together with the truth of the credible conjecture as premise. . . The whole series of mental performances between the notice of the wonderful phenomenon and the acceptance of the hypothesis . . . I reckon as composing the First Stage of Inquiry. Its characteristic formula of reasoning I term Retroduction.
> (VALUES IN A UNIVERSE OF CHANCE, p. 267)

Following Peirce (COLLECTED PAPERS, 5.189), the form of the retroductive inference can be set forth.

1. The surprising phenomenon, C, is observed; and
2. but if A were true, C would be a 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 models 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 a point of view to devise theory. In one of his essays, "On Faraday's Lines of Force", he spoke of the relationship between the point of view and the theory in terms of physical analogy.

> 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 the 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)

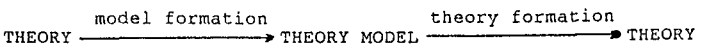
Finally, he set forth the point of view which he used to devise his theory of electricity.

> 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.



Schema 28: Theory Models Approach

The theory models approach is retroductive and so is netiher 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 more basic or general ideas are already made and waiting. To be retroductive in approach one must originate ideas.

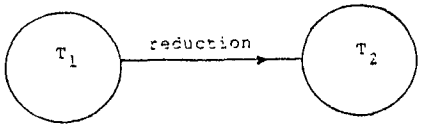
Schema 29 presents a comparison of these three approaches. Since in the reductive approach the source theory, T_1, and the wanted theory, T_2, are equivalent, T_1 and T_2 are represented by circles of the same size. In the deductive approach, T_1 is more general than T_2, which means that the source 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 started with). The retroductive approach 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 discourses. Being different discourses, no relation of implication is possible even from T_2 to T_1; yet the theory source is placed within the wanted theory, for 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 lack of distance of the theory, T_2, from its theory model formed from T_1 which results in seeing the model in the theory. 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.

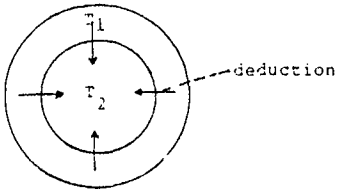
An example of the use of the theory models approach is found in DEVELOPMENT OF EDUCATIONAL THEORY DERIVED FROM THREE EDUCATIONAL THEORY MODELS, 1966.

First, a theory model was formed. The theory model was called 'SIGGS' 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 interrelation of set, information, and graph theories as they form general system theory is depicted in Schema 30.

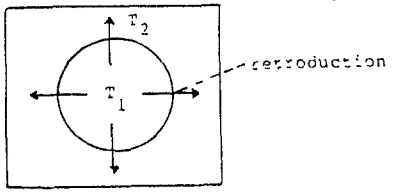
Reductive Approach



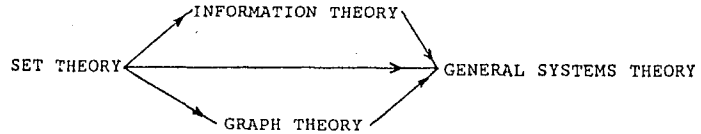
Deductive Approach



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.)



Schema 30: The SIGGS Theory Model

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

The SIGGS 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 with at least one affect relation and with information.

Stated more precisely

$$\overline{S} =_{Df} S \mid \exists \Re_A (\Re_A \neq \emptyset \wedge \forall R_A (R_A \in \Re_A \cdot \Rightarrow R_A \subset S \times S$$

$$\exists \wp (\wp \neq \emptyset \wedge \forall I (I \in \wp \cdot \Rightarrow I \sim R_A \ \overline{\vee} \ \exists \Re (\Re \subset R_A^{\geq n} \wedge I \sim \Re) \overline{\vee}$$

$$S' (S' \subset \overline{\beta} \wedge I \sim S')))))$$

where '$\overline{S}$' stands for system
'S' stands for group
'$\Re_A$' stands for a family of affect relations
'R_A' stands for an element of $\Re_A$
'$\wp$' stands for a family of informations
'I' stands for an element of $\wp$

In Appendix II, there is a translation of the logico-mathematical symbols used in the SIGGS Theory Model.

In order to present a more detailed explication of the SIGGS Theory Model, the way set theory, graph theory, and information theory function in the model now will be discussed.

Set theory is a mathematical theory which characterizes sets. 'Set' is a primitive term, and so cannot be defined. However, one can give some sense of it by means of alternative referents. A set can be thought of as a collection, a class, an aggregate, a group, etc. From these alternative referents, a set usually, although not always, has something within it which could be considered as belonging to the set: the objects of the collection, the members of the class, the points of the aggregate, the components of the group, etc. That which belongs to the set is called 'an element'. Moreover, the objects, members, points, components, etc. can themselves be taken as sets of elements; and if they are so taken, then the collection, the class, the aggregate, the group, etc. can be thought of as families of sets.

Set theory gives meaning to a system as a group of components with connections between them. A system is taken to be a group of at least two components with at least one affect relation and with information. Utilizing set theory, the group of at least two components bcomes a set of at least two elements which form a sequence. The conditions, too, are given meaning ultimately in terms of set theory. A relation between components of the system, an affect relation, is given meaning through digraph theory which is based upon set theory. Through digraph theory, the group of a

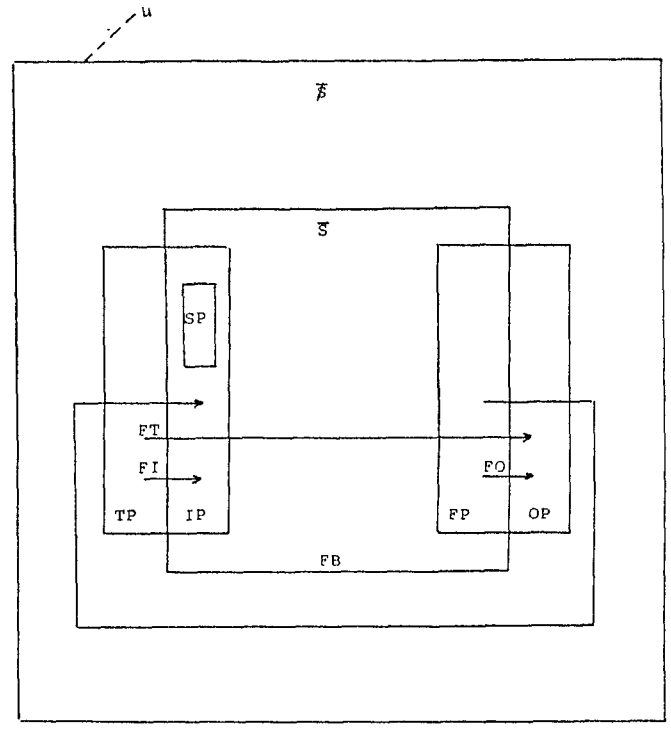
system becomes a set of points and an affect relation a set of directed lines. Not only is set used, but also the set theoretic definition of 'function'. An affect relation is a mapping of the group into itself. Through information theory, information of a system becomes a characterization of system occurrences at categories in a classification. System occurrences may 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 (toput, input, storeput, feedin, feedout, feedthrough, and feedback) and of a negasystem (fromput and output).

Only the condition of selectivity is required to give meaning to toput, input, fromput, and output. Both toput and output involve selective information on a negasystem, whereas fromput and input involve selective information on a system. Nevertheless, toput can be sorted from output, and fromput from input. Toput 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. Fromput is a negasystem property, a negasystem's environment or the selective information



'u' stands for universe of discourse	'TP' stands for toput
'S̄' stands for system	'IP' stands for input
'S' stands for negasystem	'FO' stands for feedout
'SP' stands for storeput	'FP' stands for fromput
'FT' stands for feedthrough	'OP' stands for output
'FI' stands for feedin	'FB' stands for feedback

Schema 31: Information Theoretic Properties of a System

available to a negasystem, but input is a system's property, its selective information.

The other basic information properties require conditions over and above that of selectivity. Storeput requires the selective information to be conditional, since storeput is a system selective information which results when one takes into account the dependency of system selective information upon that available to a negasystem. Feedin, feedout, feedthrough, and feedback are properties in which there is a flow of selective information, a transmission of selective information. Conditions, hence, of selective information separated by time intervals and sharing of selective information are requirements. To illustrate: feedin is shared information between toput and input, where toput is at a time just prior to the input.

Graph theory gives meaning to the kinds of connections between components. Through digraph theory, a system group becomes a set of points and system affect relations become sets of directed lines, and digraph properties of a system result when certain conditions are placed on its affect relations or its group.

Complete connection, strength, unilateralness, weakness, and disconnection exemplify digraph properties of a system arising from conditions on its affect relations. Complete connection is a property in which affect relations are direct directed ones and in which every two components are contained; there are direct channels back and forth between every two components. In strong systems the affect relations are directed ones and every two components are contained in them; there are channels back and forth between every two components but they are not direct. Although in unilateral systems affect relations are directed and every two components are contained in them, the channels are only one-way. In weak systems there are no channels, since directions are not specified. Weak systems, nevertheless, have every two components contained in the affect relations, a condition lacking in disconnected systems.

Passive dependency, active dependency, independency, and interdependency exemplify digraph properties of a system due to conditions on the group. The conditions on the group have to do with the group component containment in affect relations. In passive dependency, components are so contained that channels only go to the component; in active dependency, channels only go from them; in independency, channels do not go either to or from them; and, finally, in interdependency, channels go to and from them.

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. EXPLICATING 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 characterizations 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 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 syntactics 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:

$$E = \{t, s, c, x\}$$

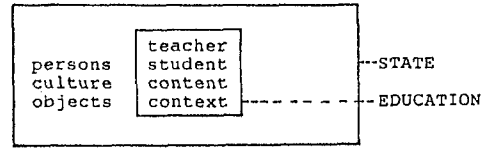
where 'E' stands for system of education
't' stands for teacher
's' stands for student
'c' stands for content
'x' stands for context

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 'negasystem'. When the system of education is considered within a state, the negasystem consists of per-

sons, 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 negasystem.

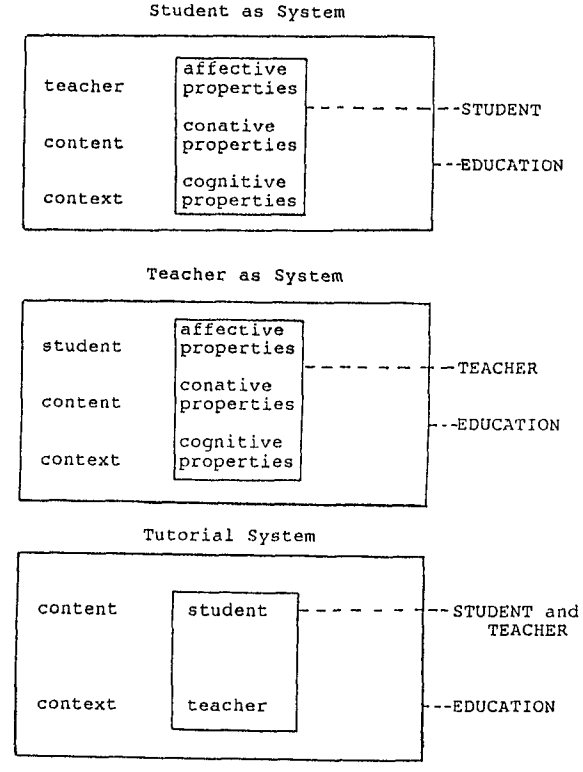


Schema 32: Education as a System

It should be noted that what is taken as a component in 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 from the state to education, the student can be taken as a system rather than as a component. One would then delineate the components within the student, i.e., the affective, conative, and cognitive properties. These properties would be the components of the system and the components other than the student--teacher, content, and context--would be those of the negasystem.

Within education one is not limited to the components as systems. A combination of components could be taken as system. The negasystem would change accordingly. The figures 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 from 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,



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 or 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 system characteristics 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.

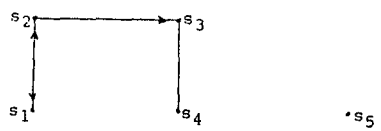


Figure 1

Figure 1 was constructed from points--s_1, s_2, s_3, s_4, s_5--and lines, some of which are arrows. There are no lines between s_5 and the other points. Thus, s_5 is not connected to or paired with any of the other points. Where there is an arrow or arrows between two points, there is a directed connection or a pairing. Consequently, there is a directed connection or pairing between s_1 and s_2, s_1 and s_3, s_2 and s_1, and s_2 and s_3. Given only one arrow between two points, the directed connection is direct as in s_1 and s_2, s_2 and s_1, 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. 'Di-' indicates that graphs consist of directed lines. Interchangeable usage of the terms 'graph theory' and 'digraph theory', therefore, is justified.) So

a directed connection is assumed between s_1 and s_4, s_2 and s_4, and s_3 and s_4 or s_4 and s_3 or both. Since the line between s_2 and s_3 has an arrow, the direction is given from s_2 to s_3 and not from s_3 to s_2. Therefore, s_3 is not paired to s_2 or s_1, and also s_4 is not paired to s_2 or s_1. To summarize, the graph in Figure 1 is expressed in a matrix

	s_1	s_2	s_3	s_4	s_5
s_1	0	1	1	1	0
s_2	1	0	1	1	0
s_3	0	0	0	1*	0
s_4	0	0	1*	0	0
s_5	0	0	0	0	0

where '*' indicates the possibility of one of the two entries being 0

and as relations

(s_1, s_2), (s_1, s_3), (s_1, s_4)

(s_2, s_1), (s_2, s_3), (s_2, s_4)

(s_3, s_4), (s_4, s_3)

From the matrix it can be seen that the total possible pairs of points in a graph of five points is twenty, and that the graph presented in Figure 1 has only seven or eight pairs out of twenty.

By adding graph theory to set theory, the complex of elements which is a system is not only interpreted as a set but also as a set of points, and the standing in interaction which is a system is not only interpreted as functions but as directed lines. This added interpretation permits the utilization of properties of graphs to give precision to certain properties of systems. For example, a system would have complete connectedness if and only if all its affect relations were direct directed ones, i.e., direct channels from and to each component. The graph presented in Figure 1 is not completely connected; rather it is disconnected. Figure 2 presents a completely connected graph.

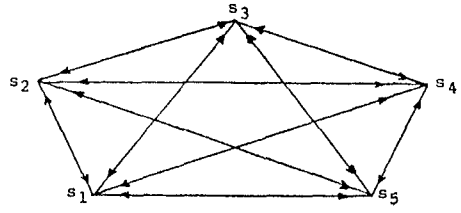


Figure 2

Utilizing graph theoretic properties in theorizing about education, transmission of culture in a group consisting of a teacher and four students will be considered. Let the point s_5 represent the teacher, s_1, s_2, s_3, and s_4 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 or 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 component, 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 uncertain 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 selection, 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 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

$$H(C_{IJ}) = \sum_{i=1}^{m} \sum_{j=1}^{n} p(c_i,c'_j) \log_2 \frac{1}{p(c_i,c'_j)}$$

The measure for conditional uncertainty would be

$$H(C_I\ C_J) = \sum_{i=1}^{m} \sum_{j=1}^{n} p(C_i,c'_j) \log p\ (c_i\ c_j)$$

The three H measures are related as follows:

$$H(C_I) + H(C_J\ C_I) = H(C_{IJ})$$

The T measure is the amount of shared information:

$$TIC_I,C_JP = H(C_i) + H(C_J) - H(C_{IJ})$$

The information theoretic notions of SIGGS provide a framework for categorizing the four major teaching-studenting 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 Bellack's initiating behavior consisting of either structuring or soliciting and reflexing behavior consisting of either responding or reacting. (THE LANGUAGE OF THE CLASSROOM, 1966) Determination is through obtaining an H measure or the amount of uncertainty for locating a given verbal behavior in any one of the categories. One could, of course, do likewise for student verbal behaviors. In fact, all elements of the education system or subsystems conceivably could be categorized thusly. Thereby, SIGGS information theoretic properties, such as toput 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 concept of feedin, which is shared information. Taking an H measure on student verbal behavior--the toput--and on teacher verbal behavior--input, then the commonality can be measured or a T measure obtained. Obviously, this could 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 educology. Hegelian theory and Marxian theory have featured as sources for the development of theory of society and theory of education.

Fichte (1762-1814), not Hegel, introduced the triad of thesis, anthithesis, and synthesis (Grundlage der gesamten Wissenschaftslehre); but the antithesis did not emerge from the thesis, and the synthesis did not go beyond both the thesis and the synthesis. It was Hegel (1770-1831) who, in the Platonic tradition, had thoughts pass over into their opposites and then achieve a higher truth. He added determinism: contradictions 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 dialetical materialism (a phrase devised by G. Plekhanov and first used in a publication in 1891). Marx (1818-1883) applied dialectic to history and so

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, workers are alienated from the means of production, and thereby alienated from society and themselves. The dialectical process will come to an end in the classless society in which there will be no division into exploited and exploiters.

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

Georges Gurvitch (1896-1965) critcized Hegel and Marx for only recognizing one form of dialectics, polarization. He also recognized complementarity, mutual involvement, ambiguity and ambivalence, and reciprocity of perspectives. Hence, there are five ways in which opposing social elements can be related to each other. Elements may complete, interpenetrate, attract or repel, and manifest in inverse ways, as well as take up conflicting positions. Gurvitch referred to his method as "hyperempiric 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 personalism and collectivism, not only between the individual and society but also within the individual. Social harmonism is a synthesis of personalism and collectivism.

Ralf Dahrendorf (1929-) developed a dialectic conflict theory of society, because of the inherent division of all social organizations into two opposing roles, those with authority and those subordinate to authority, which gave rise to social conflict. The functionalist theory of society is one of concensus and equilibrium and emphasizes shared values and social integration. Moreover, conflict is taken simply as deviance corrected by mechanisms of social control. However, conflict is as structural in social life as is concensus. 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 neo-

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. So the social structure is marked by inevitable conflict. The critical theory of the Frankfurt School (Adorno, Horkheimer, Marcuse, Fromm, Lowenthal, and Neumann are among its members) is the most explicit neo-Marxist example of dialectical sociology.

Finally, the neodialectical framework of Llewellyn Gross (1914-) should be mentioned. It is a method for building sociological theory through questions and answers, challenges and confrontations, theses and countertheses. The widest possible variety of theories, including functionalism and conflict theory (both non-Marxian theories such as Gurvitch's, Sturzo's, and Dahrendorf's and Marxian theories such as Mills', Gouldner's, and that of the Frankfurt School) should be used 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. S. Maccia (1979) has written of Harris' 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 the traditions of civilization. This self-development was taken to be one in which thoughts pass over into their opposites and then achieve a higher truth. During this century, John Dewey also treated education within a dialectical context and thus conceived education as a transaction in which experience develops toward that which is funded with the skills and habits of intelligence.

Contemporary psychologists of education, however, do not use the dialectic in their theory building. Although cognitive development is central in their theorizing, development is 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 is contrasted with 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: first schools represent a rational way of sorting and selecting talented people so that the most able and motivated attain the highest status position; second, schools teach the kind of cognitive skills and norms essential for the performance of most roles in a society increasingly dependent upon knowledge and expertise. (Hurn, pp. 30-31)

> This theory [conflict theory] portrays schools not as more or less rational instruments for sorting and selecting talented people, but as institutions that perpetuate inequality and convince lower class groups of their inferiority. In the radical [conflict] paradigm what is important about schooling is not the cognitive and intellectual skills schools teach, but the class-related values and attitudes that they reinforce. In this view, schools are instruments of elite domination, agencies that foster compliance and docility rather than independent thought and humane value. (Hurn, p. 31)

Many of the contributions to the conflict portrayal of the schools have been Marxian. One example is 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 are antithetical to 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 education is necessary, we believe, to understand the dynamics of educational change . . . (p. 124)

Although the contrast between the functional and conflict paradigms and statements such as Bowles' lead one to conclude that functionalism neglects social conflict and change, such neglect is not inherent in functionalism. The functional paradigm is suited equally to explain conflict and change and to explain order and stability. Sztompka states the matter well:

> One may analytically construct a <u>static systemic-functional model</u> 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 systemic-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 disunity, and subsystemic disintegration. (pp. 143-146)

An example of a functional paradigm equally suited to analyze any system both in its static and dynamic aspects is the SIGGS Theory Model explicated above.

Maccia and I have used SIGGS 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 not-constructing. Only lack of contradiction produces mutuality, a transactional relation in which experience is reconstructed and grows.

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

> Through social liberalism, the conception of liberal education evolves from
>
> cultivation of the intellects of Free Men for their enjoyment
>
> and
>
> cultivation of the words of Slaves for their transformation of the world through revolution

> to
>
> cultivation of the social intelligence of human beings for their freedom.
>
> Thus, from the thesis,
>
> educology of the oppressor,
>
> and the antithesis,
>
> educology of the oppressed,
>
> emerges the synthesis,
>
> educology 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 static, structure is emphasized, while mechanism is dynamic, state is emphasized. The other two possibilities for viewing the world are organicism and contextualism. Under organicism, 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 title of the view is apt. Contextualism is the dynamic counterpart to organicism; 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--its structure and its state, formism and mechanism form a pair and organicism and contextualism form another pair, I take two analogies to be the overarching ones for theorizing, the analogy of the machine and the analogy of the organism. Black has called overarching theory models, "archetypes", and Kuhn 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.

Thus, in such an object 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 combination of parts. The effects are linear and additive. Therefore, in a mechanistic state of affairs the parts are non-modifiable and are the determining factors.

An organismic point of view is one in which phenomena are represented like an organism. 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 and so fixed actions. Rather parts act interdependently to maintain function, and thereby wholeness. The parts do not simply combine and then 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 hold.

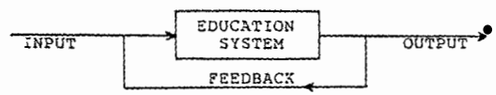
In LOGICAL AND CONCEPTUAL ANALYTIC TECHNIQUES, I recognized in educational theorizing the mechanistic point of view and called the machine model employed, "the educative effects model". Schema 34 represents such a model.

Schema 34: Educative Effects Model

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 SIGGS.

The SIGGS theory model permits representation of organized complexity. Set theory enables quantification of a complex organization as a whole; graph theory of 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.



Schema 35: Cybernetic Education Theory Model

In SIGGS as presented in Schema 31, toput and a new sense of output are added to input and output which is newly interpreted as fromput. Determination is now possible not only of what education takes in and what is available from it, but also of 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 output to input. Transmission from and 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 proable occurrences in categories of societal expressions. Taking an H measure on the culture of the teacher that is available to the student (toput 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 toput and 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. They render the indefinite definite; 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 sense for Peirce. In the sort that I made, explication has the sense of setting forth the content

and form of an already developed theory. In Peirce's sense, explication means emending 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 emending and extending theory.

As seen in 3. EXPLICATING THEORY, classification is basic to descriptive theory. 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.

In providing a set of class terms, the metaphysician utilizes the methods of deductive logic. Bifurcation is the method used in partitioning or dividing up a universe. 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 n characteristics, 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 according to two characteristics: intended and guided. 2^2 or 4 classes of learning emerged. 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 25. Then on the basis of my phenomenological analysis of education as a teaching-studenting process, I limited education to learning that is intended and guided and so emended Dewey's theory.

Another example of the use of the method of bifurcation is Walkling's classification of multicultural education curricular phenomena according to three characteristics: selective (the use of criteria to judge material about cultures to be included) and not selective (called by Walkling "tolerant"), absolutist (belief in general structuring principles of knowledge) and not absolutist (called by Walkling "relativist"), and transformationist (aiming at changing culture) and not transformationist (called by Walkling "transmissionist"). ("The Idea of a Multicultural Curriculum") Since there are three characteristics, there are 2^3 classes or 8 classes.

Moreover, Walkling's classification can be utilized as an example in theory construction of applying another principle of deductive logic, the principle of contradiction. $p\bar{p}$ is an invalid schema. Thus, classes that violate this principle should be ruled out. In Walkling'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 then one does not believe that there are no general structuring principles 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, praxiological, and scientific classes; and knowledge was sorted according to object into physical, biological, and hominological classes. These two classifications were combined through crossover (6 classes x 3 classes) to produce 18 classes. Of these 18 classes, 6 classes were ruled out as logical impossibilities. Formal knowledge--logic and mathematics--implies knowledge that has no object. Thus, physical logic, biological logic, hominological logic, physical mathematics, biological mathematics, and hominological mathematics 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, conative, and affective structures. Cognitive structures were partitioned into quantitative, qualitative, and performative ones. Quantitative structures were partitioned into instantial, theoretical, and criterial ones. Qualita-

tive structures were partitioned into recognitive, acquaintive, and appreciative ones. Finally, performative structures were partitioned into protocolic, conventional, innovative, and creative ones. So a hierarcy of classes was developed on the basis of class inclusion. To illustrate class inclusion: creative structures are contained in performative ones, performative stuctures in cognitive ones, cognitive structures in content, and content in education.

As discussed in 4. EVALUATING THEORY, classification always involves definition. A class term refers to all the particulars to which the term is applicable and has sense in terms of the characteristics that a particular must have in order for the term to be applicable. Because reference is determined by sense and a definition sets forth the sense of a term, definition is basic to classification.

The method of equivalence is used in developing definitions. The definiens must be equivalent to the definiendum. Equivalence is mutual implication (the definiendum and the definiens are logically deducible from one another) which is the validity of the biconditional formed of the definiendum and the definiens.

In systematizing definitions, the method of chaining is used. In this method the definiens of one definition becomes the definiendum of the next definition.

An example of the use of the methods of equivalence and chaining is my development of descriptive metaphysics of education. In this development, I began with my phenomenological analysis of education as a system consisting of the subsystems of teacher, student, content, and context. Then I went on to develop a chain of definitions with respect to each of the subsystems. On pages 40 through 42, some of that development is presented.

Whether one is constructing descriptive theory or explanatory theory, the method of derivation based on deductive logic is important. In this method, less general ideas are inferred from more general ones. The relation of implication is central. Implication is the validity of the conditional formed from the more general idea expressed as the antecedent and the less general idea expressed as the consequent. To be valid means that the schema comes out true under all truth valid interpretations. Thus, the case under which the conditional is false--the antecedent is true and the consequent false--is ruled out. This would be the case where implication did not hold. So implication holds.

One example from my theorizing of the use of the method of derivation is my inference about the nature of human learning from Plato's theory of the psyche. Plato's analysis of the human psyche resulted in the recognition of three psychical structures: cognitive, conative, and affective. Given that learning is development of the psyche, then learning is development of cognitive, conative, and affective structures. The deduction is as follows:

*1. $p \equiv q$

*2. $r \equiv ps$

*3. $r \equiv qs$ (1) (2) TF

4. $p \equiv q \cdot r \equiv ps \supset r \equiv qs$ *

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

Axiomization is another method that is important in constructing explanatory theory. Through axiomization theoretical sentences expressing relations between characteristics are systematized. The theoretical sentences are connected deductively, i.e., they form an axiomatic system in which for each possible interpretation of the calculus that makes the axioms (postulates) true, every theorem is likewise true (the postulates imply the theorems). In 3. EXPLICATING THEORY, there is a discussion of the method of axiomization with an example.

At least one cavet is in order with respect to the method of axiomization in social theory and so in education theory. Full formalization is impossible, since one must presuppose large segments of disciplines other than those indigenous to the theory being constructed. Psychology presupposes sociology; sociology presupposes psychology; education theory presupposes both psychology and sociology; and philosophical theory is presupposed by all three. 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 emended 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 emending 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 forms 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 a theory must either be more general than the theory or must be of the same order of generality. Hominological 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-

studenting 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 emending 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 Syntactics

1.1. Truth functional operations are negation, conjunction, alternation, conditionality, and biconditionality. These operations are ways of transforming sentences expressing propositions into other sentences expressing propositions so that the truth value of the generated sentences 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 symbolizes as follows:

1.2.1. p

1.2.2. $\bar{p}$

1.2.3. pq

1.2.4. -(pq)

where 'p' stands for leniency in grading increases learner motivation
'q' stands for leniency in grading increases learner achievement
'~' stands for not
('~' is an equivalent symbol to '-')

It should be noted that small letters of the alphabet beginning with 'p' are used to symbolize sentences expressing propositions.

The truth values of the transformed sentences, p and -(pq), depend upon the truth values of the sentences before transformation as depicted in these truth tables:

p	p
T	F
F	T

pq	-(pq)
T	F
F	T

To translate

if it is true that leniency in grading does increase learner motivation and then it is negated, 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 negated, 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 negated, 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 negated, 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

with

1.3.2. teaching is intentional

with

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 '∧' 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., 'p(qr)' is equivalent to '(pq)r'

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

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

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

p	q	r	pqr
T	T	T	T
T	T	F	F
T	F	T	F
T	F	F	F
F	T	T	F
F	T	F	F
F	F	T	F
F	F	F	F

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^n where 'n' 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

Notice that 'or both' is not stated, although it is understood. A shortened version of 1.4.3. is

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

These linguistic formations are symbolized as

1.4.1. p

1.4.2. q

1.4.3. p v q

1.4.4. p v q

where 'p' stands for learning is self-developmental
'q' stands for learning is status quo supportive
' v ' stands for either . . . or . . . or both

Alternation like conjunction is associative, commutative, and idempotent.

The truth table for alternation indicates that the alternative is false if and only if all alternates are false. In all other cases it is true.

p	q	p v q
T	T	T
T	F	T
F	T	T
F	F	F

1.5. Conditionality is a truth functional operation through which the sentences are linked by 'if . . . then . . .' so that one is an antecedent to the other which is the consequent. 'Provided . . ., . . .', 'in case . . ., . . .', and '. . . only if . . .' are equivalent to 'if . . . then . . .'. For example, to form a conditional from the two sentences,

1.5.1. the frequency of teacher-student interaction increases

1.5.2. teacher-student liking increases

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:

p	q	p ⊃ q
T	T	T
T	F	F
F	T	T
F	F	T

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 . . . then . . .'. 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:

1.6.1. p

1.6.2. q

1.6.3. p ≡ q

where 'p' stands for learners are motivated
'q' stands for learners achieve
' ≡ ' stands for 'if and only if . . . then . . .'
(' ⊃ ' is an equivalent symbol to ' ≡ ')

The truth table for biconditionality is

p	q	p ≡ q
T	T	T
T	F	F
F	T	F
F	F	T

From the table it can be seen that the biconditional is true if and only if the two sentences making it up have the same truth value. Where the truth values differ, the biconditional is false.

The biconditional is so called, because it can be written as a conjunction of two conditionals. Instead of writing

p ≡ q

one can write

(p ⊃ q)(q ⊃ p)

The example 1.6.3., therefore, would read

1.6.4. if learners are motivated then learners achieve and if learners achieve then learners are motivated

If one recalls that '. . . only if . . .' is equivalent to 'if . . . then . . .', then one can note that 1.6.4. is equivalent to

1.6.5. if learners are motivated then learners achieve, and only if learners are motivated then learners achieve

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 ⊃ p is valid, since

p	p ⊃ p
T	T
F	T

The concept of validity is important in deductive reasoning. Truth functional transformation rules of a deductive system are valid schemata. Application of these valid schemata permits 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.

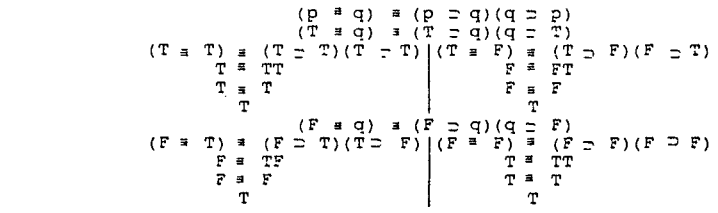
To illustrate: the deduction of r ⊃ q from p ⊃ q and r ⊃ p is established because (p ⊃ q)(r ⊃ p) ⊃ (r ⊃ q) is valid. A truth table shows that (p ⊃ q)(r ⊃ p) ⊃ (r ⊃ q) is true under all interpretations.

p	q	r	(p ⊃ q)	(r ⊃ p)	⊃	(r ⊃ q)
T	T	T	T	T	T	T
T	T	F	T	T	T	F
T	F	T	F	T	F	T
T	F	F	F	T	F	F
F	T	T	T	F	T	T
F	T	F	T	F	T	T
F	F	T	F	T	F	T
F	F	F	F	F	T	F

The decision procedure of Quine is more elegant.

(p ⊃ q)(r ⊃ p) ⊃ (r ⊃ q)
(p ⊃ F)(T ⊃ p) ⊃ (T ⊃ F)
(T ⊃ F)(T ⊃ T) ⊃ (T ⊃ F) | (F ⊃ F)(T ⊃ F) ⊃ (T ⊃ F)
FT ⊃ F | TF ⊃ F
T | T

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



True under all interpretations; therefore, valid.

2. Quantification Syntactics

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 syntactics, 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 syntactics is needed over and beyond

truth functional syntactics.

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. 'Nego' means I deny, and so its vowels 'E' and 'O' stand for negative categorial 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	PM
SM	SM	MS	MS
SP	SP	SP	SP

The moods arise from the fact that there are four kinds of categorical sentences and three in a syllogism. 4^3 equals 64. The moods are as follows:

AAA	AIA	EAA	EIA	IAA	IIA	OAA	OIA
AAE	AIE	EAE	EIE	IAE	IIE	OAE	OIE
AAI	AII	EAI	EII	IAI	III	OAI	OII
AAO	AIO	EAO	EIO	IAO	IIO	OAO	OIO
AEA	AOA	EEA	EOA	IEA	IOA	OEA	OOA
AEE	AOE	EEE	EOE	IEE	IOE	OEE	OOE
AEI	AOI	EEI	EOI	IEI	IOI	OEI	OOI
AEO	AOO	EEO	EOO	IEO	IOO	OEO	OOO

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:

Kinds of Sentences	Subject Terms	Predicate Terms
A	D	U
E	D	D
I	U	U
O	U	D

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:

Figure 1	Figure 2	Figure 3	Figure 4
Barbara	Cesare	Darapti	Fresison
Celarent	Camestres	Datisi	Bramantip
Darii	Festino	Disamis	Camenes
Ferio	Baroco	Ferison	(AEO)
(AAI)	(EAO)	Felapton	
(EAO)	(AEO)	Bocardo	

The vowels indicate the mood, e.g. Barbara is AAA. No names

were given to the forms of the syllogisms having weakened conclusions, i.e., a particular conclusion inferred from two universal premises.

The syllogism in 2.1 is Festino and so valid. Appeal to the rules also would establish validity.

2.6. Syllogistic arguments are relatively simple. Arguments usually come in more complex form, e.g.,

2.6.1. There is a teacher that all students admire

2.6.2. Therefore, every student admires some teacher or other

2.7. In contemporary quantification syntactics, the categorical sentences A, E, I, and O are symbolized as follows:

2.7.1. $(x)(Fx \supset Gx)$

2.7.2. $(x)(Fx \supset -Gx)$

2.7.3. $(\exists x)(Fx \cdot Gx)$

2.7.4. $(\exists x)(Fx \cdot -Gx)$

In the A schema, the universal quantifier '(x)' is applied so that it may be said that all F are G. The schema may be read:

2.7.1. Each x is such that if x is an F then x is a G.

Also in the E schema, the universal quantifier is applied. This application is required to say that no F are G as indicated in the readoff,

2.7.2. Each x is such that if x is an F then x is not G.

In the I schema, the existential quantifier '$(\exists x)$' is applied so that it may be said that some F are G. The schema may be read:

2.7.3. There is something x such that x is an F and x is a G.

To dispel the rendering of I as $(\exists x)(Fx \supset Gx)$, the trivi-

ality of the affirmation of such a form should be noted. This form says that there is at least one object which is non-F or G, for 'F ⊃ G' is equivalent to '$\bar{F} \vee G$'. That there is one such object is bound to be true except in the extreme case where F is true of everything in the universe.

Also in the O schema, the existential quantifier is used. '(∃x)' is applied so that it may be said that some F are not G. The schema may be read:

2.7.4. There is something x such that x is an F and x is not a G.

In all four schemata, x is merely a mark for cross-reference to a quantifier. 'F' and 'G' stand not for sentences, as 'p' and 'q' do, but for terms. Terms, of course, are finer substructures than sentences. It should be noted that '.' has been introduced for 'and' and that '(x)' is used instead of '(∀x)'.

2.8. Terms can be either absolute or relative. Relative terms differ from absolute terms insofar as they describe objects relative to further objects. For example, in the sentence cited in 2.6,

2.6.1. There is a teacher that all students admire

'teacher' and 'student' are absolute terms, while 'admire' is a relative one. 'Fy' may be used to symbolize y is a teacher and 'Gx' to symbolize x is a student, but x admires y cannot be so symbolized. The symbolization presented in 2.7 is patently insufficient. To render x admires y, a two-place predicate is required; it is symbolized as Hxy. Besides dyadic terms, there are also triadic ones, tetradic ones, and so on; for example, 'Hxyzw' may stand for x teaches y to z in w.

To complete the symbolization of 2.6.1, symbolization must be extended even more beyond 2.7. Quantifications within quantifications must be symbolized. Within the existential quantification, there is a teacher, there is an universal quantification, all learners admire. Consequently, 2.6.1 is symbolized as follows:

2.6.1. $(\exists y)[Fy \cdot (x)(Gx \supset Hxy)]$

which may be read as follows:

2.6.1. There is somebody y such that y is a teacher

and each x is such that if x is a student then x admires y.

Moreover, in the conclusion cited in 2.6,

2.6.2. Every student admires some teacher or other

the quantifications are reversed so that the existential quantification is within the universal as the symbolization shows clearly:

2.6.2. $(x)[Gx \supset (\exists y)(Fy \cdot Hxy)]$

2.9. Although the rules of the syllogism were developed for determining the validity of three-term two-premise arguments, their use may be extended to many-term many-premise arguments provided these arguments can be broken down into syllogistic parts. The limits of the syllogistic method, however, cannot be transcended where arguments include relative terms and quantifications within quantifications. Other rules are required.

These rules are as follows: universal instantiation (UI), existential generalization (EG), universal generalization (UG), existential instantiation (EI), and truth functional inference (TF). UI and EG are obvious, where each thing is an F one may infer an instance, i.e., (x)(Fx) implies Fy, and where there is an instance one may infer that there is something, i.e., Fy implies (∃x)(Fx). UG and EI, however, seem wrong-headed. It appears that one cannot conclude all from an instance or an instance from there being something. But UG and EI are not such strong claims. What is claimed is not

$$Fy \supset (x)(Fx) \text{ or } (\exists x)(Fx) \supset Fy$$

but only these existential quantifications,

$$(\exists y)[Fy \supset (x)(Fx)] \text{ or } (\exists y)[(\exists x)(Fx) \supset Fy]$$

That only existenial quantification of the conditional is claimed is indicated by noting--"flagging" according to Quine--the variable involved. 'Variable' here is not used in a mathematical sense, but simply has the sense of a pronoun that cross-references a quantifier. To allow for these weakened links and yet have a justifiable deduction, in a given deduction no variable may be flagged more than once, and when flagged the variable must be alphabetically later than all the other free variables of the schema it flags. A

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:

* 1. $p \supset q$

* 2. $r \supset p$

* 3. $r \supset q$ (1) (2) TF

4. $(p \supset q)(r \supset p) \supset (r \supset q)$ *

The first star stands for suppose and the succeeding stars indicate consequences 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:

* 1.	$(\exists y)]Fy \cdot (x)(Gx \supset Hxy)]$	
* 2.	$Fy \cdot (x)(Gx \supset Hxy)$	(1) EI y
• 3.	Fy	(2) TF
• 4.	$(x)\ (Gx \supset Hxy)$	(2) TF
• 5.	$Gx \supset Hxy$	(4) UI
** 6.	Gx	
** 7.	$Fy \cdot Hxy$	(3)(5)(6) TF
** 8.	$(\exists y)(Fy \cdot Hxy)$	(7) EG
* 9.	$Gx \supset (\exists y)(Fy \cdot Hxy)$	*
• 10.	$(x)[Gx \supset (\exists y)(Fy \cdot Hxy)]$	(9) UG x
11.	$(\exists y)[Fy \cdot (x)(Gx \supset Hxy)] \supset (x)[Gx \supset (\exists y)(Fy \cdot Hxy)]$*	

It should be noted that on the right hand side when the rules that demand flagging are used, i.e., EI and UG, 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--8 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.	$\ldots =_{Df} \_\_\_$	... equals by definition ___
2.	$\{\ldots\}$	set of elements ...
3.	$\ldots \mid \_\_\_$	... such that ___
4.	$\ldots \leq \_\_\_$	... is less than or equal to ___
5.	$\ldots \wedge \_\_\_$	... and ___
6.	$\ldots \geq \_\_\_$	... is greater than or equal to ___
7.	$\ldots = \_\_\_$	... is equal to ___
8.	$\iota \ldots(\_\_\_)$	that ... such that ___
9.	$\ldots \in \_\_\_$	... is an element of ___
10.	$\exists \ldots(\_\_\_)$	there is a ... such that ___
11.	$\ldots < \_\_\_$	... is less than ___
12.	$(\ldots, \_\_\_, n)$	n-tuple of ... and ___ and n
13.	$\ldots(\_\_\_)$	... at ___
14.	$\ldots \prec \_\_\_$	... precedes ___
15.	$\ldots + \_\_\_$	... plus ___
16.	$\ldots \subset \_\_\_$	... is contained in ___
17.	$\ldots \times \_\_\_$	Cartesian product of ... and ___
18.	$\ldots \neq \_\_\_$	... is not equal to ___
19.	$\forall \ldots(\_\_\_)$	for all ..., ___
20.	$\ldots \Rightarrow \_\_\_$	... only if ___
21.	$\ldots \notin \_\_\_$	... is not an element of ___
22.	$\ldots \sim \_\_\_$	... is equivalent to ___
23.	$\ldots \bar{\vee} \_\_\_$	either ... or ___ and not both
24.	$\ldots 2^n$	power set of ...
25.	$C_{\ldots \_\_\_}$	complement of ___ with respect to ...
26.	$n(\ldots)$	cardinality of ...
27.	$\lvert \ldots \rvert$	absolute value of ...
28.	$\Delta \ldots$	increment of ...
29.	$\ldots - \_\_\_$	... minus ___
30.	max ...	maximum ...
31.	$\bigcup_{i=1}^{n} \ldots i$	union of ... where .. is indexed from 1 to n
32.	$\ldots \cup \_\_\_$	union of ... and ___
33.	$\bigwedge_{i=1}^{n} \ldots i$	conjunction of ... where ... is indexed from 1 to n
34.	$\ldots \cap \_\_\_$	intersection of ... and ___
35.	$\ldots > \_\_\_$	... is greater than ___
36.	$\ldots \rightarrow \_\_\_$	... into ___
37.	$\sum_{i=1} \ldots i$	summation of ... where ... is indexed from 1 to n
38.	$\bigcup_{e \in \_\_\_} \ldots e$	union of ... as e varies over ___

39. $\sum_{e \in ---} \ldots_e$	summation of ... as e varies over ---
40. $\ldots \vdash ---$	... yields ---

APPENDIX III

The SIGGS Theory Model is presented as follows

1. citation of term which takes the form, n. ...,---

   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. ... is ---.

   where '.1' stands for a natural language definition
   '...' stands for a definiendum
   '---' stands for a definiens

   2.2. logco-mathematical definiton which takes the form, n.2. $\ldots =_{Df}$ ---

   where '.2' stands for a logico-mathematical definition
   '$=_{Df}$' stands for equals by definition

1. universe of discourse,

2. component, s

3. group, S

   3.1. A group is at least two components that form a unit within the universe of discourse.

   3.2. $S =_{Df} \{ s_i \mid 1 \leq i \wedge i \leq n \wedge n \geq 2 \}$

4. characterization, CH

5. information, I

5.1. Information is characterization of occurrences.

5.2. $I =_{Df} CH \mid CH = \{c \mid \iota p((c,v,) \in p)\}$

5-1. selective information, I_S

5-1.1. Selective information is information which has alternatives.

5-1.2. $I_S =_{Df} I \mid \exists c((c,v) \in p \wedge 0 < v \wedge v < 1)$

5-1-1. nonconditional selective information, I_S

5-1-1.1. Nonconditional selective information is selective information which does not depend on other selective information.

5-1-1.2. $I_S^N =_{Df} I_S \mid \exists n(n \geq 1 \wedge I = C_{I_1 I_2 \cdots I_n})$

5-1-2. conditional selective information, I_S

5-1-2.1. Conditional selective information is selective information which depends upon other selective information.

5-1-2.2. $I_S^C =_{Df} I_S \mid I \in C_{I|J}$

6. transmission of selective information, $I(I_S, I_S, \ldots, I_S, \ldots, I_S)$

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

6.2. $I(I_{S_1}, I_{S_2}, \ldots, I_{S_i}, \ldots, I_{S_n}) =_{Df} T(I_{S_1}(t_1), I_{S_2}(t_2), \ldots, I_{S_i}(t_i), \ldots, I_{S_n}(t_n))$ $\quad t_i < t_{i+1}$

7. affect relation, R_A

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

7.2. $R_A =_{Df} R \mid R \subset S \times S \wedge R \neq \emptyset \wedge \forall(s_i, s_j)$

7-1. directed affect relation, R_{DA}

7-1.1. A directed affect relation is an affect relation in which one or more components have a channel to one or more other components.

7-1-2. $R_{DA} =_{Df} R \mid R \subset S \times S \wedge R \neq \emptyset \wedge \forall(s_i, s_j)$ $((s_i, s_j) \in R \cdot \supset \cdot s_j \in \Gamma_O(s_i) \wedge s_i \neq s_j)$

7-1-1. direct directed affect relation, R_{DA}^D

7-1-1.1. A direct directed affect relation is a directed affect relation in which the channel is through no other components.

7-1-1.2. $R_{DA} =_{Df} R_{DA} \mid s_j \in \Gamma^1(s_i)$

7-1-2. indirect directed affect relation, R_{DA}^I

7-1-2.1. An indirect directed affect relation is a directed affect relation in which the channel is through other components.

7-1-2.2. $R_{DA} =_{Df} R_{DA} \mid s_j \notin \Gamma^1(s_i) \wedge s_j \in \Gamma_O(s_i)$

8. system, S

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

8.2. $\overline{S} =_{Df} S \mid \exists \alpha_A(\alpha_A \neq \emptyset \wedge \forall R_A(R_A \in \alpha_A \cdot \supset \cdot R_A \subset S \times S \wedge \exists \omega(\omega \neq \emptyset \wedge \forall I(I \in \omega \cdot \supset \cdot I \sim R_A \vee \exists \kappa(\kappa \subset R_A^n \wedge I \sim \kappa) \vee \exists S'(S' \subset S \wedge I \sim S'))))))$

9. negasystem, $\bar{S}$

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

9.2. $\bar{S} =_{Df} C_{\iota} S \mid C_{\iota} S \neq \emptyset$

10. condition, E

11. system state, $ST_{\overline{S}}$

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

11.2. $ST_{\overline{S}} =_{Df} \{\underline{E} \mid \iota\overline{S}(\iota t(\underline{E}(\overline{S}(t))))\}$

12. negasystem state, $ST_{\not\overline{S}}$

12.1. A negasystem state is a negasystem's conditions at a given time.

12.2. $ST_{\not\overline{S}} =_{Df} \{\underline{E} \mid \iota\not\overline{S}(\iota t(\underline{E}(\not\overline{S}(t))))\}$

13. system property, $P_{\overline{S}}$

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

13.2. $P_{\overline{S}} =_{Df} \{\overline{S} \mid \underline{E}(\overline{S})\}$

14. negasystem property, $P_{\not\overline{S}}$

14.1. A negasystem property is a negasystem's conditions.

14.2. $P_{\not\overline{S}} =_{Df} \{\not\overline{S} \mid \underline{E}(\not\overline{S})\}$

15. value, V

16. system property state, $ST_{P_{\overline{S}}}$

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

16.2. $ST_{P_{\overline{S}}} =_{Df} \iota V_t P_{\overline{S}} \iota t(V(P_{\overline{S}}(t)))$

17. negasystem property state, $ST_{P_{\not\overline{S}}}$

17.1. A negasystem property state is a negasystem property's value at a given time.

17.2. $ST_{P_{\not\overline{S}}} =_{Df} \iota V_t P_{\not\overline{S}} \iota t(V(P_{\not\overline{S}}(t)))$

18. system environment, $E_{\overline{S}}$

18.1. System environment is a negasystem of at least two components with at least one affect relation which has selective information.

18.2. $E_{\overline{S}} =_{Df} \{\overline{S} \mid n(\not\overline{S}) \geq 2 \wedge \exists R_A(R_A \neq \emptyset \wedge \forall R_A(R_A \in R_A . \Rightarrow R_A \subset \not\overline{S} \times \not\overline{S} \wedge \exists \mathcal{O}_S(\forall I_S \in \mathcal{O}_S . \Rightarrow I_S \sim R_A \overline{V} \exists R(R \subset R_A^{2^n} \wedge I_S \sim R) \overline{V} \exists S'(S' \subset \not\overline{S} \wedge I_S \sim S')))))$

19. negasystem environment, $E_{\not\overline{S}}$

19.1. Negasystem environment is a system with selective information.

19.2. $E_{\not\overline{S}} =_{Df} \{\not\overline{S} \mid (\overline{S} \mid I_S(\overline{S})(\not\overline{S})\}$

20. system environmental change, $EC_{\overline{S}}$

20.1. System environmental change is a difference in system environment.

20.2. $EC_{\overline{S}} =_{Df} \{\overline{S} \mid |ST_{E_{\overline{S}}}(t + \Delta t) - ST_{E_{\overline{S}}}(t)| \geq \delta\}$

21. negasystem environmental change, $EC_{\not\overline{S}}$

21.1. Negasystem environmental change is a difference in negasystem environment.

21.2. $EC_{\not\overline{S}} =_{Df} \{\not\overline{S} \mid |ST_{E_{\not\overline{S}}}(t + \Delta t) - ST_{E_{\not\overline{S}}}(t)| \geq \delta\}$

22. toput, TP

22.1. Toput is system environment.

22.2. $TP =_{Df} E_{\overline{S}}$

23. input, IP

23.1. Input is a system with selective information.

23.2. $IP =_{Df} \{\overline{S} \mid I_S(\overline{S})\}$

24. fromput, FP

24.1. Fromput is negasystem environment.

24.2. $FP =_{Df} E_{\not\overline{S}}$

25. output, OP

25.1. Output is a negasystem with selective information.

25.2. $OP =_{Df} \{\vec{\beta} \mid I_S(\vec{\beta})\}$

26. storeput, SP

26.1. Storeput is a system with input that is not fromput.

26.2. $SP =_{Df} I_S(IP|FP)$

27. feedin, FI

27.1. Feedin is transmission of selective information from a negasystem to a system.

27.2. $FI =_{Df} \vec{I}(TP,IP)$

28. feedout, FO

28.1. Feedout is transmission of selective information from a system to a negasystem.

28.2. $FO =_{Df} \vec{I}(FP,OP)$

29. feedthrough, FT

29.1. Feedthrough is transmission of selective information from a negasystem through a system to a negasystem.

29.2. $FT =_{Df} \vec{I}(TP,IP,FP,OP)$

30. feedback, FB

30.1. Feedback is transmission of selective information from a system through a negasystem to a system.

30.2. $FB =_{Df} \vec{I}(FP,OP,TP,IP)$

31. filtration, FL

31.1. Filtration is restriction of environment.

31.2. $FL =_{Df} |\max ST_{TP} - ST_{TP}| \geq \delta$

32. spillage, SL

32.1. Spillage is restriction of feedin.

32.2. $SL =_{Df} |\max ST_{FI} - ST_{FI}| \geq \delta$

33. regulation, RG

33.1. Regulation is adjustment of fromput.

33.2. $RG =_{Df} |ST_{FP}(t + \Delta t) - ST_{FP}(t)| \geq \delta$

34. compatibility, CP

34.1. Compatibility is commonality between feedin and feedout.

34.2. $CP =_{Df} B(FI,FO)$

35. openness, O

35.1. Openness is either feedin or feedout.

35.2. $O =_{Df} ST_{FI} + ST_{FO} - ST_{CP} = \delta$

36. adaptability, AD

36.1. Adaptability is difference in conpatibility under system environmental change.

36.2. $AD =_{Df} |ST_{CP}(t + \Delta t) - ST_{CP}(t)| \geq \delta \wedge EC_S$

37. efficiency, EF

37.1. Efficiency is commonality between feedthrough and toput.

37.2. $EF =_{Df} B(FT,TP)$

38. complete connectivity, CC

38.1. Complete connectivity is every two components directly channeled to each other with respect to affect relations.

38.2. $CC =_{Df} \exists R'_A(R'_A \subset R_A \wedge \forall R_A \in R'_A \Rightarrow R_A = R^{\beta}_{DA} |$

$(s_j,s_i) \in R))$

39. strength, SR

39.1. Strength is not complete connectivity and every two components are channeled to each other with respect to affect relations.

39.2. $SR =_{Df} \exists \pi'_A(\pi'_A \subset \pi_A \wedge \forall R_A(R_A \in \pi'_A . \supset R_A \neq R^D_{DA} \wedge R_A = R_{DA} \mid (s_j,s_i) \in R))$

40. unilateralness, U

40.1. Unilateralness is not either complete connectivity or strength and every two components have a channel between them with respect to affect relations.

40.2. $U =_{Df} \exists \pi'_A(\pi'_A \subset \pi_A \wedge \forall R_A(R_A \in \pi'_A \supset R_A = R_{DA} \mid (s_j,s_i) \notin R))$

41. weakness, WE

41.1. Weakness is not either complete connectivity or strength or unilateralness and every two components are connected with respect to affect relations.

41.2. $WE =_{Df} \exists \pi'_A(\pi'_A \subset \pi_A \wedge \forall R_A(R_A \in \pi'_A \supset R_A \neq R_{DA}))$

42. disconnectivity, DC

42.1. Disconnectivity is not either complete connectivity or strength or unilateralness or weakness and some components are not connected with respect to affect relations.

42.2. $DC =_{Df} \exists \pi'_A(\pi'_A \subset \pi_A \wedge \forall R_A(R_A \in \pi'_A \supset \exists(s_i s_j)((s_i,s_j) \notin R_A)))$

43. vulnerability, VN

43.1. Vulnerability is some connections which when removed produce disconnectivity with respect to affect relations.

43.2. $VN =_{Df} \exists \pi'_A(\pi'_A \subset \pi_A \wedge \forall R_A(R_A \in \pi'_A . \supset R_A = R \mid R \subset S \times S \wedge \exists R'(R' \subset R \wedge DC(S \mid R - R'))))$

44. passive dependency, D_P

44.1. Passive dependency is components which have channels to them.

44.2. $D_P =_{Df} \exists A(A \subset S \wedge \forall s(s \in A \supset \overline{\Gamma}_O(s) \neq \emptyset))$

45. active dependency, D_A

45.1. Active dependency is components which have channels from them.

45.2. $D_A =_{Df} \exists A(A \subset S \wedge \forall s(s \in A \supset \Gamma_O(s) \neq \emptyset))$

46. independence, I

46.1. Independence is components which do not have channels to them.

46.2. $I =_{Df} \exists A(A \subset S \wedge A \neq S \wedge \forall s(s \in A \supset \overline{\Gamma}_O(s) = \emptyset))$

47. segregation, SG

47.1. Segregation is independence under system environmental change.

47.2. $SG =_{Df} \mid ST_I(t + \Delta t) - ST_I(t) \mid \leq \varepsilon \wedge EC_S$

48. interdependency, ID

48.1. Interdependency is components which have channels to and from them.

48.2. $ID =_{Df} \exists A(A \subset S \wedge \forall s(s \in A \supset . \Gamma_O(s) \neq \emptyset \wedge \overline{\Gamma}_O(s) \neq \emptyset))$

49. wholeness, W

49.1. Wholeness is components which have channels to all other components.

49.2. $W =_{Df} \exists A(A \subset S \wedge \forall s_i(s_i \in A \supset \forall s_j(s_j \neq s_i \supset s_j \in \Gamma_O(s_i))))$

50. integration, IG

50.1. Integration is wholeness under system environmental change.

50.2. $IG =_{Df} | ST_W(t + \Delta t) - ST_W(t) | \leq \varepsilon \wedge EC_{\Sigma}$

51. hierarchical order, HO

51.1. Hierarchical order is levels of subordination of components in each level with respect to affect relations.

51.2. $HO =_{Df} \exists \pi_{DA}(\pi_{DA} \subset \pi_A \wedge \forall R_A \in \pi_{DA} \cdot \Rightarrow R_A = (\bigcup_{i=1}^{n} R_i) \cup (\bigcup_{i=1}^{n+1} R'_i) \wedge \bigwedge_{i=1}^{n} (R_i \cap R_{i+1} = R'_i \cap R'_{i+1} = R_i \cap R'_i = O) \wedge \bigwedge_{i=1}^{n+1} (R'_i = \bigcup_{j=1}^{m} R'_j \wedge SR(R'_j)) \wedge \bigwedge_{i=1}^{n} (D(R_i) \subset R(R'_i) \wedge R(R_i) \subset D(R'_{i+1}) \wedge R_i \neq \emptyset)))$

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. $F =_{Df} \exists \pi_{DA}(\pi_{DA} \subset \pi_A \wedge \forall R_A(R_A \in \pi_{DA} \cdot \Rightarrow \exists \sigma(\forall s_i(s_i \in S \Rightarrow \forall s_j(s_j \in S \wedge (s_i, s_j) \in R_A \Rightarrow \exists S'(S' \in \sigma \wedge \exists S''(S'' \in \sigma \wedge S' \cap S'' = \{s_i, s_j\} \wedge \exists m(m \geq 1 \wedge \exists n(n > 1 \wedge s_j \in \Gamma^m_{S'}(s_i) \wedge s_j \in \Gamma^n_{S''}(s_i)))))))))$

53. homomorphism, HM

53.1. Homomorphism is components having the same connections as other components.

53.2. $HM =_{Df} \exists S'(S' \subset S \wedge \exists S''(S'' \subset S \wedge \exists \sigma(\sigma \mid S' \rightarrow S''))$

54. isomorphism, IM

54.2. $IM =_{Df} \exists S'(S' \subset S \wedge \exists S''(S'' \subset S \wedge \exists \sim(\sim \mid S' \rightarrow S'')))$

55. automorphism, AM

55.1. Automorphism is components whose connections can be transformed so that the same connections hold.

55.2. $AM =_{Df} \exists S'(S' \subset S \wedge \exists \sim(\sim \mid S' \rightarrow S'))$

56. compactness, CO

56.1. Compactness is average number of direct channels in a channel between components.

56.2. $CO =_{Df} \exists p(\exists s_i(s_i \in S \wedge \exists s_j(s_j \in S \wedge \forall s_k(s_k \in S \Rightarrow \forall s_m(s_m \in S \cdot d(s_i, s_j) \geq d(s_k, s_m) \wedge \exists n(n = ST_{SZ} \wedge \sum_{\substack{k=1 \\ m=1 \\ k \neq m}}^{n} \frac{d(s_i, s_j) - d(s_k, s_m)}{n^2 - n} = p))))))$

57. centrality, CE

57.1. Centrality is concentration of channels.

57.2. $CE =_{Df} \exists A(A \subset S \wedge \forall B(B \subset S \Rightarrow \exists \pi_{DA}(\pi_{DA} \subset \pi_A \wedge \forall R_{DA}(R_{DA} \in \pi_{DA} \Rightarrow \sigma R_{DA}(B) \subset \sigma R_{DA}(A)))))$

58. size, SZ

58.1. Size is the number of components.

58.2. $SZ =_{Df} n(\{s_1, \ldots, s_n\})$

59. complexity, CX

59.1. Complexity is the number of connections.

59.2. $CX =_{Df} n(\bigcup_{R_A \in \pi_A} R_A)$

60. selective informationness, SI

60.1. Selective informationness is amount of selective information.

60.2. $SI =_{Df} \sum_{c \in I} p(c) \log \frac{1}{p(c)}$

61. size growth, ZG

61.1. Size growth is increase in size.

61.2. $ZG =_{Df} ST_{SZ}(t + \Delta t) \geqq ST_{SZ}(t)$

62. complexity growth, XG

62.1. Complexity growth is increase in complexity.

62.2. $XG =_{Df} ST_{CX}(t + \Delta t) \geqq ST_{CX}(t)$

63. selective information growth, TG

63.1. Selective information growth is increase in selective information.

63.2. $TG =_{Df} ST_{SI}(t + \Delta t) \geqq ST_{SI}(t)$

64. size degeneracy, ZD

64.1. Size degeneracy is decrease in size.

64.2. $ZD =_{Df} ST_{SZ}(t + \Delta t) \leqq ST_{SZ}(t)$

65. complexity degeneracy, XD

65.1. Complexity degeneracy is decrease in complexity.

65.2. $XD =_{Df} ST_{CX}(t + \Delta t) \leqq ST_{CX}(t)$

66. selective information degeneracy, TD

66.1. Selective information degeneracy is decrease in selective information.

66.2. $TD =_{Df} ST_{SI}(t + \Delta t) \leqq ST_{SI}(t)$

67. stability, SB

67.1. Stability is no change with repect to conditions.

67.2. $SB =_{Df} ST_{\bar{S}}(t_1) \cap ST_{\bar{S}}(t_2) \neq \emptyset$

68. state steadiness, SS

68.1. State steadiness is stability under system environmental change.

68.2. $SS =_{Df} | ST_{SB}(t + \Delta t) - ST_{SB}(t) | \leqq \sigma \wedge EC_S$

69. state determinancy, SD

69.1. State determinancy is derivability of conditions from one and only one state.

69.2. $SD =_{Df} \exists \mathfrak{S}T'_{\bar{S}}(\forall ST'_{\bar{S}}(ST'_{\bar{S}} \in \mathfrak{S}T'_{\bar{S}} \wedge ST'_{\bar{S}}(t + \Delta t) .\Rightarrow$
$\exists A(A \subset ST'_{\bar{S}} \wedge \nexists ST''_{\bar{S}}(ST''_{\bar{S}} \in \mathfrak{S}T_{\bar{S}} \wedge ST''_{\bar{S}}(t) \wedge$
$ST''_{\bar{S}} \vdash A))))$

70. equifinality, EL

70.1. Equifinality is derivability of conditions from other states.

70.2. $El =_{Df} \exists \mathfrak{S}T'_{\bar{S}}(\forall ST'_{\bar{S}}(ST'_{\bar{S}} \in \mathfrak{S}T'_{\bar{S}} \wedge ST'_{\bar{S}}(t + \Delta t) .\Rightarrow$
$\exists A(A \subset ST'_{\bar{S}} \wedge \exists \mathfrak{S}T''_{\bar{S}}(\mathfrak{S}T''_{\bar{S}} = \{ST''_{\bar{S}} \mid 1 \leqq i \wedge i \leqq n \wedge$
$n \geqq 2\} \wedge \forall ST''_{\bar{S}}(ST''_{\bar{S}} \in \mathfrak{S}T''_{\bar{S}} \wedge ST''_{\bar{S}}(t) .\Rightarrow$
$ST''_{\bar{S}} \vdash A)))))$

71. homeostasis, HS

71.1. Homeostasis is equifinality under system environmental change.

71.2. $HS =_{Df} |ST_{EL}(t + \Delta t) - ST_{EL}(t)| \leqq \delta \wedge EC_S$

72. stress, SE

72.1. Stress is change beyond certain limits of negasystem state.

72.2. $SE =_{Df} |ST_S(t + \Delta t) - ST_S(t)| \geqq \delta$

73. strain, SA

73.1. Strain is change beyond certain limits of system state.

73.2. $SA =_{Df} |ST_S(t + \Delta t) - ST_S(t)| \geq \delta$

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.

PRIMITIVE

1. universe of discourse,
2. component, s
4. characterization, CH
10. condition, F
15. value, V

DEFINED

3. group, S
5. information, I
5-1. selective information, I_S
5-1-1. nonconditional selective information, I_S^N
5-1-2. conditional selective information, I_S^C
6. transmission of selective information, $I(I_{S_1}, I_{S_2}, \ldots, I_{S_i}, \ldots, I_{S_n})$
7. affect relation, R_A
7-1. directed affect relation, R_{DA}
7-1-1. direct directed affect relation, R^D_{DA}
7-1-2. indirect directed affect relation, R^I_{DA}
9. negasystem, $\not S$
12. negasystem state, $ST_{\not S}$
14. negasystem property, $P_{\not S}$
17. negasystem property state, $ST_{P_{\not S}}$
19. negasystem environment, $E_{\not S}$
21. negasystem environmental change, $EC_{\not S}$
24. fromput, FP
25. output, OP

Table 1: Indirect System Descriptions

(19, 21, 24, and 25 are negasystem properties.)

NON-PROPERTIES

8. system, $\bar{S}$
11. system state, $ST_{\bar{S}}$
13. system property, $P_{\bar{S}}$
16. system property state, $ST_{P_{\bar{S}}}$

PROPERTIES

18. system environment, $E_{\bar{S}}$
20. system environmental change, $EC_{\bar{S}}$
22. toput, TP
23. input, IP
26. storeput, SP
27. feedin, FI
28. feedout, FO
29. feedthrough, FT
30. feedback, FB
31. filtration, FL
32. spillage, SL
33. regulation, RG
34. compatibility, CP
35. openness, O
36. adaptability, AD
37. efficiency, EF
38. complete connectivity, CC
39. strength, SR
40. unilateralness, U
41. weakness, WE
42. disconnectivity, DC
43. vulnerability, VN
44. passive dependency, D_P
45. active dependency, D_A
46. independency, I
47. segregation, SG
48. interdependency, ID
49. wholeness, W
50. integration, IG
51. hierarchical order, HO
52. flexiblity, F
53. homomorphism, HM
54. isomorphism, IM
55. automorphism, AM
56. compactness, CO
57. centrality, CE
58. size, SZ
59. complexity, CX
60. selective information, SI
61. size growth, ZG
62. complexity growth, XG
63. selective information growth, TG
64. size degeneracy, ZD
65. complexity degeneracy, XD
66. selective information degeneracy, TD
67. stability, SB
68. state steadiness, SS
69. state determinancy, SD
70. equifinality, EL
71. homeostasis, HS
72. stress, SE
73. strain, SA

Table 2: Direct System Descriptions

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