Viewing the world systemically.

Theory Construction in the Social Sciences

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To understand the place of theory in the social sciences, it is instructive to review the different interpretations of theory that have been proposed. In particular, it is critical to understand that hypotheses do not result in theory and the almost total reliance of the social sciences on hypothesis testing is the primary reason why there are no generally accepted theories in the social sciences, and none that are comprehensive, consistent, complete and axiomatic. Probably the biggest problem that social scientists have to confront is the prevailing methodology of classical science. Classical science is dependent on the following techniques for the development of theory: observation, hypothesis, and experiment. This is an inductive process, and one that is counter to what Peirce and Steiner have clearly analyzed. Both before and after Peirce, and before and after Steiner, the classical development of theory in the social sciences has been attempted; that is, the process of induction.

The reason that the social scientist has relied on induction and the resulting hypothesis-driven research methodology is that the social scientist interpreted the physical scientist as having developed theory by just such a method. However, such has been misguided. It is instructive to recognize that a physicist may consider the development of theory to be that of the classical science, even though it is not. Since a physicist is not so much concerned with the process of theory development as with the development of theory, this confusion is understandable. Therefore, while a physicist may assert that the development of theory is by induction, as claimed for Rock Theory (discussed below), in fact physicists developing such theory proceed in a manner defined by Peirce and Steiner as retroduction in the vertical development of new theory. Therefore, when a social scientist attempts to apply the theory-development methodology of physics; for example, as defined by a physicist, the social scientist may believe what the physicist asserts—that the methodology is one of induction. Hence, the inabilities of the social scientist to in fact develop theory—the wrong methodology is being applied.

This misinterpretation of theory development in the physical sciences has led to some of the following attempts to design a process by which theory can be developed in the social sciences.

Karl Raimund Popper. It is instructive to note that Karl Popper recognized the problems with the classical approach to the development of theory. As an alternative, Popper proposed a new scientific methodology. In his two books, *The Logic of Scientific Discovery*[1] and *Conjectures and Refutations*[2], he introduced an alternative to inductive inference for theory building—*hypothetico-deductive scientific method for theory development*.

While this approach may appear to be better than the inductive method, it falls short of clearly defining a methodology that will result in scientific theory. In fact, it but jumps to the hypothesis and explicates the "theory" from there. 'Hypothetico-deductive' is simply a process whereby we deductively determine outcomes from a hypothesis, but the hypothesis is not theory. And an outcome derived from a hypothesis that is not founded in theory is without foundation. As a result the tested hypotheses are just statements created by a researcher for the sole purpose of carrying out an experiment comparable to the classical approach they were to replace. In fact, this is so even if the hypothesis is a deduction from another hypothesis. Deductive inferences are no more reliable than the hypotheses upon which they are founded when the hypothesis is not derived from axioms, basic assumptions.

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[1] Popper, K., (1961), *The Logic of Scientific Discovery*, Basic Books, New York.

[2] Popper, K., (1963), *Conjectures and Refutations*, Routledge & Kegan Paul, New York.

The difference between the physical and other mathematical sciences and the social sciences is that in physics and the other mathematical sciences, there is an underlying theory upon which all hypotheses rely. In the social sciences there is none. It is not that there is a distinction between what the scientists in the physical sciences and social sciences define as 'theory', it is just that in the physical sciences a theory of physics, etc., has actually been developed. So the question is simply, why has no such theory been developed in the social sciences, and in education, in particular?

In physics the researcher proceeds from an existing theory, whether that is Newtonian Physics, Einstein Physics, the Kinetic Theory of Gases, Thermodynamics, or some other theory, and this theory provides the framework in which the scientist works. Hypotheses in physics are in fact derived from an existing theory.

Then, ***the <u>predictions</u> derived therefrom determine the value of the theory***. This is the critical point relating to theory construction—its main purpose is to *predict*. Further, the predictions of the theory provide new outcomes that no intuition or hypothesis could have predicted. While hypotheses in the social sciences are designed to state what someone believes to be true, and, clearly, cannot state anything that the designer cannot conceive, the purpose of a theory is distinctly different as follows, and is so stated by Shutt above. Further, the main point here is that while some statements of a theory may in fact be a "theory", if they do no more than state the obvious, the "theory" is of little value. With this in mind, we have the following:

> **Purpose of a Theory—**If there are no counterintuitive results derived from a theory, or if there are no predictions from the theory that are not obvious, or if the theory does not provide outcomes that were not seen, or if the theory does not obtain results that are otherwise difficult to obtain, then there is no need for the theory.
>
> Predictions from a theory are a result of equations (mathematical models) or logical derivations developed from the theory and such equations or logical schema does not rely on any preconceived notions that the effect could even exist.
>
> Therefore, ***the purpose of a theory is to provide the means to develop mathematical, analytical, or descriptive models that predict counterintuitive, non-obvious, unseen, or difficult-to-obtain outcomes***.

When all we are testing are outcomes that are preconceived, then we are missing the very purpose of scientific inquiry—to determine what it is that we do not know, rather than that which we have just not yet confirmed, or patterns that we have just not yet discerned.

Confirmation of a hypothesis may be interesting and of limited value, but to call a body of knowledge that does nothing more than confirms perceptions of known events is to trivialize the notion of theory to the point where any proclamation becomes a *theory*. That this is done all too frequently is confirmed by the "Charles's Law Theory" asserted by Travers as discussed below.

In fact, it is interesting to note that Popper (Popper, 1963) asserts, yet does not recognize the methodology of theory development when he cites this very **<u>non</u>**-hypothetico-deductive example:

> We all were thrilled with the result of Eddington's eclipse observations which in 1919 brought the first important confirmation of Einstein's theory of gravitation.[3]

[3] Ibid., p. 34.

Clearly, Einstein's theory was not devised as a result of any observation. The observation was initiated as a direct result of the deductive inferences of the theory. Einstein's "hypothesis" concerning light and gravitation was obtained deductively from his theory; that is, it was a *logically-derived, theory-based hypothesis*, and not from some hypothesis founded on an observation. A hypothesis is not a theory, and this example by Popper refutes the very nature of scientific discovery that Popper claims.

Robert Morris William Travers. While others before him recognized the problems with the classical approach to the development of theory, Robert Travers embraces it completely to the point of asserting that theory is developed directly from the data of observations. In 1972, R.M.W. Travers published a book entitled *An Introduction to Educational Research*[4]. Therein, Travers states:

> In the behavioral sciences, one common practice is for the scientist to develop theories that postulate underlying mechanisms to account for behavior as it is observed. ... These imaginary mechanisms are known as *constructs*. (pp. 14-15)
>
> The problem that is eventually isolated may be stated in terms of a question for which the proposed research is designed to obtain an answer. Sometimes the question to be answered is referred to as a hypothesis. (p. 81).
>
> **It will be assumed in this discussion that the hypothesis is firmly rooted in a framework of theory.** (p. 81) [Emphasis added.]

Travers confirms that research in the behavioral sciences as practiced is concerned with explaining observed behavior, rather than developing theories that encompass such behavior. This is an important distinction. Theories encompass observations; they guide the researcher to look in certain directions; they inform the researcher about outcomes that were never conceived; most important, they do not just reflect what someone observes.

First, it must be established beyond doubt but that theory is not derived from observations, and, in particular not from any collection of data. Observation may suggest phenomena for which a legitimate theory could assist in predicting outcomes, but the theory itself must come from some other source. For example, once it is proposed from observation that the earth travels in an orbit around the sun, and is then confirmed by further observation, a question might be: What keeps the earth in this orbit rather than traveling off into space?

It is clear that no "gravity waves" were observed, and, therefore, no empirical data identifying gravity is available by which some "theory" could be derived that would describe *gravity*. The theory is clearly derived from some other means—*it is the imagination and creative insight of the innovator by which theory is developed*. Social scientists seem to miss this very important aspect of theory development. Theory is developed as the result of personal insight, and not by some mechanical means by which observations are classified into patterns for analysis.

With respect to gravity, we start with *Newton's Law of Universal Gravitation*—a statement about the relationship between bodies. This statement is not a theory; it simply defines mathematically what can be observed concerning the "gravitational attraction," the effect of the construct called "gravity," between two physical bodies. It tells us nothing about what gravity is.

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[4] Travers, R.M.W., (1972), *An Introduction to Educational Research*, The Macmillan Company, New York.

Further, there are numerous theories of gravity. One of the more well-known theories is *Einstein's General Relativity Theory of Gravity* from which *Newton's Law* can be derived. Other theories of gravity include: The *Dynamic Theory of Gravity*, the *Inertial Theory of Gravity*, and the *String Theory of Quantum Gravity*. It should be clear that none of these, especially *String Theory*, were obtained by collecting data.

The "isolated problem" cited by Travers is posed as a hypothesis. Surprisingly, Travers asserts that "*the hypothesis is firmly rooted in a framework of theory*." But, what theory is he referring to? Travers, quoting F.N. Kerlinger, defines 'theory' as follows:

> A theory may be defined as "a set of interrelated constructs (concepts), definitions, and propositions that presents a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena"[5].
>
> Theories knit together the results of observations, enabling scientists to make general statements about variables and the relationships among variables. For example, it can be observed that if pressure is held constant, hydrogen gas expands when its temperature is increased from 20° to 40°C. It can be observed that if pressure is held constant, oxygen gas contracts when its temperature is decreased from 60° to 50°C. A familiar theory, Charles's Law, summarizes the observed effects of temperature changes on the volumes of all gases by the statement "When pressure is held constant, as the temperature of a gas is increased its volume is increased and as the temperature of a gas is decreased its volume is decreased." The theory not only summarizes previous information but predicts other phenomena by telling us what to expect of any gas under any temperature change.[6]

Travers, like many before and after him from the social sciences, attempts to rely on theory construction in the physical sciences, and physics, in particular, to justify his vision of how theory is developed. Unfortunately, such vision is tainted by a misinterpretation resulting from a misunderstanding of just how theory in physics is actually developed. While it is legitimate to use theory from physics as a paradigm for theory construction in the social sciences, when that paradigm is misunderstood, legitimate theory in the social sciences is compromised.

Travers asserts:

> Theories knit together the results of observations.

As cited previously, it is clear that theories of gravity were not obtained as the result of observing gravity and *Newton's* ***Law*** is not theory.

Newton's Law may have "knit together the results of observations," but theories of gravity were not derived for such knitting; they were derived for something far more substantive—to explain what gravity is in terms of predicting the effects of such gravity, such as the bending of light rays. The bending of light rays was not observed until a theory of gravity was developed that predicted such light ray bending. The observation confirmed the theory; the theory was not derived to somehow explain an observation. In terms of Steiner and Thompson:

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[5] Kerlinger, Fred N., (1973). *Foundations of Behavioral Research*, 2nd ed., New York: Holt, Rinehart and Winston, p. 9.
[6] Ibid., p. 15.

- Retroduction devises theory—the Theory of Relativity was devised.
- Deduction explicates theory—it was explicated that light rays bend in the presence of large gravitational fields.
- Abduction extends theory—mathematical models assisted in extending and explicating the Theory of Relativity. Who does not recognize $e = mc^2$?
- Induction evaluates theory—the empirical event of a solar eclipse was used to evaluate whether or not light rays actually bend.

By citing *Charles's Law* as an example of what behavioral scientists consider as "theory," Travers confirms that the behavioral scientist is not concerned with the development of theory—*Charles's Law* is **not** a "theory." "*Knitting together results of observations*" does **not** develop theory.

Charles's Law determines specific ratios of certain empirical events, a process of abduction whereby mathematics is used to help interpret observed events. It does not design a theory concerning such events; it simply establishes equations by which such events can be measured.

The *Ideal Gas Law* is a generalization of both *Boyle's Law* and *Charles's Law*. The *Kinetic Theory of Gases* encompasses the *Ideal Gas Law*.

For example, although the *Kinetic Theory of Gases* describes the motion of many particles and how the kinetic energy of those particles produces an averaged effect of pressure, its axioms were not obtained or predicted by observing the rising of a balloon filled with gas, as was *Charles's Law*. The three assumptions upon which the *Kinetic Theory of Gases* is based are:

- Matter is composed of small particles (molecules or atoms).
- The particles are in constant motion.
- When the particles collide with each other, or with the walls of a container, there is no loss of energy.

These axioms are assumed from general considerations of matter, and not the specific filling of a balloon with gas. Further, these axioms were not obtained as the result of any observations; they were presumed as the result of the *creative insight of the researcher*. At the time that these axioms were propounded, neither molecules nor atoms could be seen. It was simply *assumed* that they existed. And, there certainly is no way to determine whether or not these particles are ever at rest, although the *preponderance of evidence* indicates that they are not. And, likewise there is no way to determine if in fact there is never any loss of energy, it is simple assumed that there is none. However, even today, atoms in gases cannot be seen, only detected and only atoms in solids can typically be seen.

It is patent that these axioms were not obtained as the result of "observation" of any empirical event.

The *Theory of Thermodynamics* is the theory of physics that encompasses the *Kinetic Theory of Gases*. Therefore, *Charles's Law* is not a theory, but an explication of the *Theory of Thermodynamics* or its sub-theory, the *Kinetic Theory of Gases*.

These theories, while explaining certain empirical observations such as those relating to gases, were not developed as a result of Charles's observations; they were developed to explain the behavior of large volumes of particles in gases.

Once again, the social scientist has misunderstood the meaning of theorizing by which theories for the social sciences can actually be developed. The paradigm of theory development in physics is of little value if it is not understood. Theory development in physics as in any other science is the result of the logical process of retroduction by which relationships are recognized as an emendation of a point of view, whether that point of view is devised from existing theory or from the *whole cloth of relevant knowledge*.

Retroduction is the result of the imagination of the innovator and not by the mechanical process of data-mining techniques by which data-patterns are devised. Data-mining is certainly an important pursuit, although quite mechanical in nature, but it does not lead to the *creative development of theory—it is the imagination and creative insight of the innovator by which theory is developed*.

Donald Ary, Lucy Cheser Jacobs, and Asghar Razavieh. In 1985, Ary, et al., in *Introduction to Research in Education*,[7] continue to promote the misinterpretation of how theory is developed. However, the misinterpretation is now directed at believing that when explicating a theory, that the premises; that is, axioms, must be "true." They assert:

> We must begin with true premises in order to arrive at true conclusions. (p. 5) … The conclusions of deductive reasoning are true only if the premises on which they are based are true. (p. 6)

<u>Unfortunately, such is not the case</u>. The premises, axioms, must only be *presumed* to be *valid*, not *true*. For example, with respect to the three axioms cited above concerning the *Kinetic Theory of Gases*, there was no way to tell whether or not they are in fact *true*—but the scientist simply proceeded as though they were *valid*, without question. Even being able to see atoms and molecules does not make the first axiom *true*, it but *validates* the axiom and adds to the *preponderance of evidence* that in fact the axiom is *valid*. The axiom predicted that molecules and atoms would be found, and continued experiments confirmed its *validity*. Might matter be composed of something other than "small particles"? Who knows, since we have not yet had a chance to examine all of the matter in the universe? But, at this time all physicists proceed as though all matter is so composed, since the *preponderance of evidence* indicates that they should be.

Until researchers in the social sciences understand the import of this position, no legitimate theory in education or any other social science is possible.

In addition to misunderstanding the nature of assumptions, or axioms, in the development of scientific theory, Ary, et al., also confuse the place of deduction and induction in the process of theory development. They provide the following examples:

> The difference between deductive and inductive reasoning may be seen in the following examples:
>
> A. Deductive: Every mammal has lungs.
All rabbits are mammals.
Therefore, every rabbit has lungs.
>
> B. Inductive: Every rabbit that has ever been observed has lungs.
Therefore, every rabbit has lungs. (pp. 6-7)

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[7] Ary, D., Jacobs, L.C., and Razavieh, A., (1985), *Introduction to Research in Education*, Holt, Rinehart and Winston, New York.

First, the example of deduction provided is that of a syllogism and not from an axiomatic theory. They are not the same. However, assuming that axiomatic deductive inferences are also included, and that the example given for induction can be appreciated, the interpretation of induction is also misleading. What has actually been demonstrated by the inductive inference is that the observations of rabbits with lungs have confirmed the deductive inference that they in fact do have lungs—the observations have *validated* the assumption with their continuing *preponderance of evidence*. Induction *validates* theory, it does not develop theory. The validation has contributed to the *preponderance of evidence* that supports the deductive inference, and, therefore, the theory.

Most telling is their lament:

> In spite of their use of the scientific approach and accumulation of a large quantity of reliable knowledge, education and the other social sciences have not attained the scientific status typical of the natural sciences. The social sciences have not been able to establish generalizations equivalent to the theories of the natural sciences in scope of explanatory power or in capability to yield precise predictions. (p. 19)

What they fail to recognize is the reason for this lack of theory development.

As Popper (Popper, 1961) points out:

> [A] science needs a point of view, and theoretical problems.[8]

And, as he confirms, the amassing of huge amounts of data does not, and cannot, amount to theory. If one were to amass the daily traffic flow at a major city intersection, one would have a large amount of data providing "reliable knowledge" about such traffic flow. However, other than gaining the knowledge that may indicate that a traffic light is required, there is nothing by which a scientific theory could be developed. This is the state of affairs in the social sciences—great amounts of knowledge have been acquired from hypothesis testing, but <u>it is absolutely of no value for the development of an education or any other social science theory</u>.

Rather than adhering to a process referred to as "the scientific approach," it would be more constructive to recognize that possibly even physical scientists do not follow "the scientific approach" and move to determine just what it takes to develop a theory for educologists and other social scientists. Theories in physics were not developed as the result of the "accumulation of a large quantity of reliable knowledge," they were developed as the result of the *creativity, insight and innovativeness of the researcher* to recognize emendations of existing theories or from the *whole cloth of relevant knowledge*. Until the social scientist recognizes what has to be done to be creative, the lament of Ary, et al., will continue to characterize the search for legitimate theory in the social sciences.

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[8] Popper, K., (1961), *The Logic of Scientific Discovery*, Basic Books, New York, p. 106.

A Challenge to Learning Theorists

Who is there among Learning Theorists who can take the 21 "theories of learning" cited previously and devise a theory based on first principles, basic assumptions, which will encompass every one of these 21 sets of hypotheses? That is what is needed in the social sciences—a Learning Theoretician who has the *insight and creativity* to bring under one umbrella all of the diverse hypotheses that have been propounded and validated with hundreds, even thousands, of tests. Once this is accomplished, then the validations of hypotheses will have some meaning, as they will validate the theory. As it is now all they do is contribute to the "large quantity of reliable knowledge"—but such knowledge is meaningless in terms of predicting any future outcomes and do nothing to help develop legitimate Learning Theory.

Stating hypotheses in a vacuum without their associated theory will result in confusion when trying to identify the underlying assumptions. Although Travers recognized the need to anchor hypotheses in theory, he failed to recognize what that theory had to entail. Regardless of how careful one is when preparing a hypothesis, it is almost certain that hidden or unknown assumptions have not been stated. Hypotheses must be part of some theory structure, or they are nothing more than the opinion of the researcher, even if that opinion is subsequently "validated." It is this process of hypothesis-creation that has resulted in numerous "tests" of the same subject area resulting in differing conclusions—for example, "human involvement is responsible for a substantial part of global warming," versus "humans are responsible for less than 7% of the global warming effect, and global warming will therefore occur regardless of what humans do"; or "placing girls and boys together in the same class results in better learning for all students," versus "separating boys and girls for instruction results in better learning for all students." Is it possible that with both of these hypotheses, especially the latter, that there are unstated political agendas at work that compromise the integrity of the validation?

The problem is not necessarily the tests that provide differing results, but that there is no full recognition of the underlying assumptions of the theory in which the hypothesis is stated. Theory generates hypotheses, hypotheses do not create theory nor are they themselves theory. Theory, hidden or clearly stated, produces *logically-derived, theory-based hypotheses*, or theorems in more formal theories.

The problem with the hypothetico-deductive methodology is that it does not produce theory. In education, this process has never resulted in any new theory.

To correct this problem a theory-building process that leads to legitimate theory will be presented. A proper methodology requires testing *theory-derived hypotheses* and all new applications derived from the hypotheses until the evaluations lead to a new theory that describes the problem based on first principles, "accepted and *valid assumptions*"—<u>not</u> "*true* premises."

Glaser and Strauss. As an alternative to the hypothetico-deductive methodology, Glaser and Strauss developed the *Grounded Theory* approach (Glaser, 1967). Although subsequent to the publication of their joint text Glaser and Strauss have been involved in some on-going disputes concerning the details of the approach, essentially all such approaches are flawed at the outset by grounding any theory development on acquired data.

However, their dissatisfaction with hypothesis-driven research is well taken. The problem is that they did not recognize the underlying reason for this dissatisfaction—hypothetico-deductive methodologies or any other hypothesis-based methodology itself does not develop theory.

The *Grounded Theory* approach asserts that theory is "discovered" as the result of systematically analyzing data. As a result, this approach is very similar to, if not identical to the data mining procedures used to structure unstructured data. The response to each is the same, structuring unstructured data is certainly helpful in recognizing established patterns within systems to evaluate existing theory, but it does not produce theory.

An inductive process grounded or not, does not develop theory, whether one claims that induction was responsible for directly proposing a theory or the theory is deductively inferred from hypotheses—neither process actually resulted in theory construction.

Even trying to argue, as they do, that *Grounded Theory* is in some way associated with Peirce's abduction fails to provide a basis for theory construction. First, *abduction* is not *retroduction*. Glaser and Strauss consider *Grounded Theory* as a means for obtaining theory from data patterns—that is, data mining techniques. Theory development is a retroductive process, and not an inductive process nor an abductive process. In this case, 'abduction' as 'retroduction' is misinterpreted.

Since *Grounded Theory* is relied upon in the social sciences, we need to take a closer look at just what they say. Concerning Grounded Theory:

> Most important, it works—provides us with relevant predictions, explanations, interpretations and applications.[9] (p. 1)

This should not be surprising, since the purported theory is a direct reflection of the data. Whether or not such direct reflection provides "relevant predictions" that could not be otherwise observed is questionable. The final three criteria go directly to the fact that theory is in fact not being developed. What is being developed is akin to *Charles's Law of Gases* and *Newton's Law of Universal Gravitation*; that is, *Grounded "Theory"* is doing nothing more or less than describing what one observes concerning the interrelations of phenomena as defined by the data—"explanations, interpretations and applications."

One of the more telling representations is that it is claimed that theory is "discovered":

> The basic theme in our book is the discovery of theory from data systematically obtained from social research. (p. 2)

It seems as though theories are out there somewhere just waiting to be "discovered" as one would discover any other empirical event or object. It should be clear that they are not.

[9] Glaser, B.G. and Strauss, A.L., (1967), *The Discovery of Grounded Theory: Strategies for Qualitative Research*, Chicago, Aldine Publishing Company.

While one must applaud both Glaser and Strauss for their dissatisfaction with theory development in the social sciences, their solution does nothing to further that end. It is pretty much irrelevant whether your hypothesis is derived *a priori* or from the ground up, hypotheses do not generate theories. To clearly discern the nature of the statements being developed, consider the following *discovery and generation of a performance-reward process* cited by Glaser and Strauss:

> In a study of organizational scientists, the analyst discovered that scientists' motivation to advance knowledge was positively associated with professional recognition for doing so. This finding suggested the theoretical inference that recognition from others maintains motivation. [Tests then followed to theoretically verify this "theoretical inference."] (p. 212)

Once again, theory seems to be something that we "discover." However, more to the point, this appears to be nothing more than an attempt to describe an event, in the same way that *Charles's Law of Gases* and *Newton's Law of Universal Gravitation* describe empirical facts. While such descriptions are certainly applicable to any number of incidents, that does not make such descriptive correlations a theory; it simply means that one has made a rather universal observation that; for example, when people are in a position of power without controls, they will abuse their position. Regardless of how many groups one analyzes to accumulate data that further confirms this observation, no theory has been developed. It may be an interesting observation, but it is not a theory.

Essentially, the scientific methodology of the social sciences has been hypothesis-driven. That is, the definitions of both induction and hypothetico-deduction theory-building methodologies are such that each relies on a hypothesis that is devoid of the foundations required of a legitimate theory.

Retroduction develops legitimate theory, whether that retroductive process results from the development of new theory from existing theory or the development of new theory from the *whole cloth of relevant knowledge*. For example, the existing theories of Set Theory, Information Theory, Graph Theory and General Systems Theory can be used to develop theory in a very analytic manner, as was done for the development of the SIGGS theory model. Alternatively, a *whole cloth* perspective of mathematics, education, chemistry, physics and the behavioral sciences develops theory by recognizing a wholeness of concepts they contain that provide a perspective that describes and predicts what is found in education systems. For example, *General Systems Theory* was developed from a *whole cloth perspective*. And, it is most likely that the challenge given previously to Learning Theorists will be resolved by one who has the insight and creativity to bring together from a *whole cloth perspective* the theories of mathematics, education, chemistry, physics and the behavioral sciences.

Further, as Popper and others have recognized, theory must be axiomatic with all of its associated safeguards. In addition, as cited above, the social sciences have attempted to produce theories that have a rigor similar to the physical sciences by introducing mathematical constructs. Although descriptive theories are possible, only logico-mathematical foundations provide the means required for general acceptance and validation. Moreover, it is essential that if logic and mathematics symbolisms are a part of a descriptive theory they are not so by mere reference, cited without substance, but the logic and mathematics must be an integral part of the theory.

This is where historical and current research in education and the social sciences generally has failed, as research continues to proceed from a position of validating hypotheses. Education research is hypothesis-driven, rather than theory-driven. While axiomatic logico-mathematical theories are far more difficult and complex than hypothesis-driven methodologies, such theories are required if educology is to move beyond a "My Theory" methodology to that of developing a consistent, comprehensive, complete, and axiomatic theory of education. And to simply assert *a priori* that formal, axiomatic, or mathematical theories cannot apply to the social sciences is a clear refutation of any "scientific process" and places such social "scientists" outside the realm of science.

To assist in bridging the gap from hypothesis-driven to axiomatic-theory-driven science, a parallel development in physics will be considered. Even in physics, which is frequently considered as being "proven" or "empirically valid," theories are considered to be acceptable for describing the physical world as a result of a "preponderance of evidence" that they produce accurate predictions of the physical world. The same will hold in the social sciences; that is, a theory is accepted because of the "preponderance of evidence" that it produces consistently valid predictions.

Following is an example of the retroductive development of a theory in physics.

Rock Theory

Desired Theory:	Electrical Properties of Rocks
Existing Theory:	Electrical Properties of Glass

By conjecture: *the electrical properties of rocks are similar to the electrical properties of glass*.

Therefore, the existing *Electrical-Glass-Property Theory* is used to retroductively develop an *Electrical-Rock-Property Theory*.

This new *Rock Theory* is an emendation of the existing *Glass Theory*. As such, it brings with it the basic logic of that theory, which is comparable to other theories in physics; but, in addition it introduces new content and the resulting *Rock Theory* will contain more than what was brought to it from *Glass Theory*. *Glass Theory* provided the devising model by which *Rock Theory* is developed.

It is important to recognize that this is not an inductive process in that there is no extensive data from which "patterns" are developed that "suggest" that somehow rocks are similar to glass. To the contrary, it was the *Glass Theory* itself that was utilized to develop *Rock Theory* as the result of the *insight of the innovator* who recognized that the properties of the two mediums may be similar.

Levels of Theory Construction

There are several levels of theory construction required, especially in an axiomatic theory, before the actual desired empirical theory is obtained. These levels are discussed below, and an example from physics is presented on the pages following.

The first level consists of defining the *Basic Logics*; that is, the Sentential, Predicate, Class and Relation Calculi.

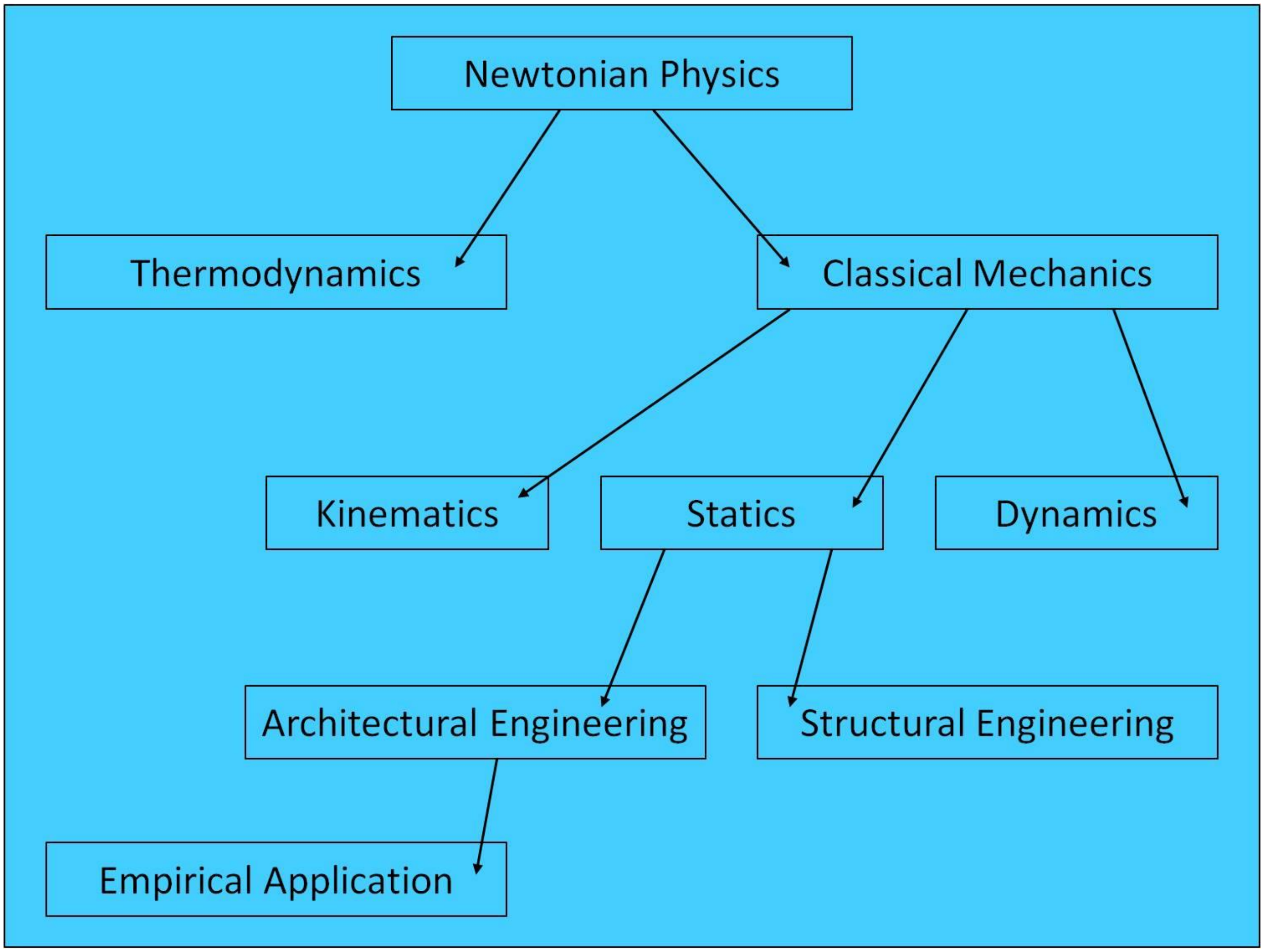
The Basic Logics provide the decisional rules by which theorems are formally derived within the theory. These provide the customary deductive logic used in physics.

Once the decisional logic is determined, then the levels of scientific inquiry must be defined. These will each require its own axioms or other structure that will be used to deduce the outcomes of the theory.

Various areas of physics will exemplify the relation between various levels of a theory. Then, the axioms or laws will be tracked to exemplify how each higher-order theory affects the lower-order theories.

In axiomatic theories, this will be accomplished by the introduction of appropriate axioms at each level.

The following tree diagram depicts various levels of theories in physics in which each lower level is dependent on the axioms or laws of the one above it, but will also introduce axioms, laws or principles that are extended from those above it.



That is, recalling that the development of theory is by emendation or extension, once the initial theory has been designed by an emendation of another theory; for example, by means of a retroductive process, then the theory is constructed by extension. These extensions can be horizontal; that is, within the existing theory, or vertical; that is, by introducing sub-theories. This vertical development is shown in the following diagram. So as not to make the diagram too complex, only one area of physics is extended to the following vertical level below it; for example, “Mechanics” and then “Statics.”

It is recognized that Thermodynamics has sub-theories extending below it, as do Kinematics and Dynamics. However, we will only consider the development of each of the following theories as one is extended from the one above it:

Newtonian Physics → Classical Mechanics → Statics → Architectural Engineering

Newtonian Physics

At this level we are concerned with the axioms, hypotheses, or principles that are used to explicate Newtonian Physics. In Newtonian Physics these statements are referred to as “laws” or “postulates.”

Newton’s Laws of Motion:

Newton's first law states that, if a body is at rest or moving at a constant speed in a straight line, it will remain at rest or keep moving in a straight line at constant speed unless a force acts upon it.

This postulate is known as the law of inertia.

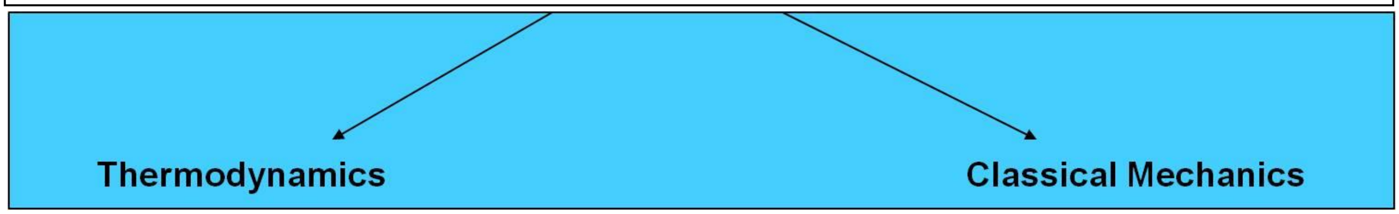
Newton's second law states that the time rate of change of the velocity or acceleration, a, is directly proportional to the force F and inversely proportional to the mass m of the body; i.e., $a = F/m$, or $F = ma$.

From the second law, all of the basic equations of dynamics can be derived. As noted previously, this initial theory provides the main assumptions by which all extensions of the theory are obtained.

Newton's third law states that the actions of two bodies upon each other are always equal and directly opposite.

The third law is important in statics (bodies at rest) because it permits the separation of complex structures and machines into simple units that can be analyzed individually with the least number of unknown forces.

Newton's law of gravitation is a statement that any particle of matter in the universe attracts any other with a force, F, varying directly as the product of the masses, m_1 and m_2, and a gravitational constant, G, and inversely as the square of the distance between them, R; i.e., $F = G(m_1 m_2)/R^2$.



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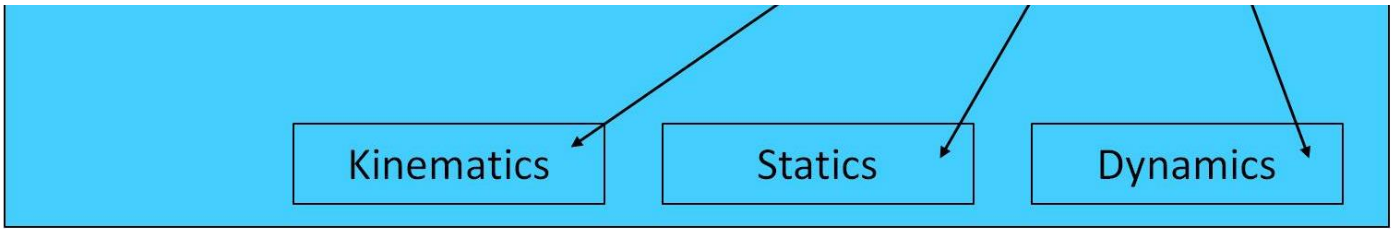
Classical Mechanics: At this level we are concerned with the axioms, hypotheses, or principles that are used to explicate Classical Mechanics.

Classical Mechanics is a theory of the physics of forces acting on bodies.

The first three laws of Newtonian Physics are fundamental to Classical Mechanics and the extensions required for this theory.

In order to consider the problems relevant to Classical Mechanics, the definition of the '*position*' of a '*point particle*' is introduced. This is an extension of Newtonian Physics. With the introduction of a *point particle*, the three laws are used to develop properties relevant to Classical Mechanics. For example, properties relating to force and energy are developed from Newton's Second Law.

Classical Mechanics is subdivided into: Statics, Kinematics, and Dynamics. We will continue our vertical theory development by considering Statics.



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Statics: At this level we are concerned with the axioms, hypotheses, or principles that are used to explicate Statics.

Statics is concerned with physical systems that are in static equilibrium. When in static equilibrium, the system is either at rest or moving at constant speed. By Newton's Second Law, this situation implies that the net force and net torque on every subsystem is zero. From this constraint, and the properties developed in Classical Mechanics, such quantities as stress or pressure can be derived.

1. When a wire is pulled tight by a force, F, the **stress**, σ, is defined to be the force per unit area of the wire: $\sigma = F / A$. The amount the wire stretches is called strain.

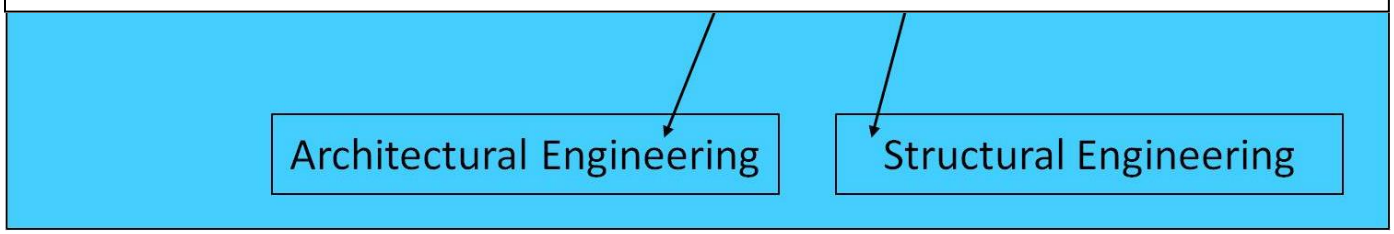
2. Failure occurs when the load exceeds a critical value for the material; the tensile strength multiplied by the cross-sectional area of the wire, $F_c = \sigma_t A$.

The theory has now been extended to include properties required for the Theory of Statics. From here, specific properties will be required for specific areas of application as shown by the next level.

Although not considered, the following definitions are provided:

Kinematics: Kinematics is the branch of mechanics concerned with the motions of objects without being concerned with the forces that cause the motion.

Dynamics: Dynamics is the branch of mechanics that is concerned with the effects of forces on the motion of objects.



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Architectural Engineering: At this level we are concerned with the axioms, hypotheses, or principles that are used to explicate Architectural Engineering as an application of the Physics Theory of Statics.

For example, at this level the theory extension will be with respect to specific physical problems of concern to architectural engineers. For example, axioms, hypotheses, or principles related to the analysis of architectural structures to preclude structural failures, construction defects, expansive soils, explosions, fires, storms/hail, tornadoes, vehicular impacts and water leaks.

The theory at this level will then be used to analyze specific empirical instances.