THE COPENHAGEN INTERPRETATION: AN ALTERNATIVE PARADIGM FOR CURRICULUM THEORIZING

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CHAPTER I

INTRODUCTION

Significance of the Study

For centuries, humankind has had an innate desire to order and comprehend its environment. This desire for knowledge has stimulated the minds of scholars towards providing answers to the myriad questions concerning the universe. Through ideas, which are created by humans, individual societies and their scholars have pursued the order and ultimate comprehension of nature. This same desire for order and understanding exists in the field of curriculum. Curriculum theorists have, therefore, augmented their own ideas by borrowing ideas from other disciplines in an effort to bring insight into curriculum theory (Dobson and Dobson, 1987).

Historically, curriculum studies have borrowed heavily from the field of science; thus, science has provided the template through which ideas concerning curriculum have been developed (Doll, 1989). Spencer's search in 1880 for the knowledge that was of most worth marked the beginning of this scientific influence upon the field of curriculum. Once Spencer opened the door of curriculum theory to scientific methods, other curriculum theorists followed suit. Theorists such as Bobbitt and Charters discovered many areas in curriculum in which scientific methods were applicable.

As curriculum theorists began to apply scientific concepts and terminology to curriculum, the nomenclature no longer was used merely to

describe a concept or methodology, but in time, began to describe "reality" in schools. This originally borrowed descriptive language thus transcended its initial purpose and evolved into a definition or description of reality. Consequently, as this applies to education, "Language, which is intended to explain or describe reality, becomes reality" (Dobson and Dobson, n.d., p. 4).

In an effort to understand curriculum theory, it behooves one to understand the scientific methods that have been borrowed to formulate the concepts in curriculum theory. Scientists realize that their theories determine or mold what they see. Does it not hold true then, that the concepts used to structure curriculum theory determine what will become reality in education? Palmer (1987, p. 16) stressed, ". . . the way we know has powerful implications for the way we live." He further implied that the epistemology will, in time, evolve into an ethic. If this is true, then the dominant scientific methods of a culture can offer tremendous insight into curriculum theory.

The scientific world that curriculum reformers of the early twentieth century (Bobbitt, Charters, Huxley, Spencer) mirrored has become known as "classical science," which rested upon the knowledge gained and research techniques employed by scientists such as Galileo, Descartes, and Newton. Their knowledge base was centered around a reductionist frame of reference (i.e., the breakdown of wholes into their most elementary parts) and therefore produced a mechanical world. This reductionist mentality allowed scientists to assume that the whole was no more than the sum of the individual parts and if one could understand the causal relationship between the parts, the whole could be reconstructed. Such a mechanical concept not only gave scientists insight into the understanding of whole entities, but also provided them the means to make

predictions concerning future behavior. These scientists of the sixteenth and seventeenth centuries refashioned the scientific community with the discovery that the earth was not the center of the universe, and with the concept that material and matter consisted of a multitude of basic, tiny objects which could be variously assembled into different and larger structures.

These scientific discoveries created an objective reality in which the observers were segregated from their environments and could therefore observe and comprehend that environment in its entirety. It allowed for no interaction or modification resulting from the presence of the individual. This reality also utilized the Cartesian method of analysis, which required breaking down the whole and then arranging the elements according to causal law. Consequently, reality became predictable and deterministic. Galileo, Descartes, and Newton henceforth began to describe the world and its entities in terms of a machine and this world-machine concept became the dominating metaphor of the time. It was because of these principles that science and society began thinking in terms of absolute truths.

Just as classical scientists sought to understand nature by breaking down whole entities, so too did curriculum reformers seek to understand the schooling process by analyzing the various components and their relationships that constitute school. Curriculum was perceived as a series of predetermined objectives that students work towards through specified learning objectives. These objectives provided the route by which students obtained knowledge that had been deemed most important.

The student body was also broken down into age groups and, in many cases, these age groups were subsequently divided according to ability. Consequently, whether it be by the breakdown of curriculum and/or the

student body, through Cartesian style analysis, educational reformers set out to improve the schooling process and curriculum through scientific means. These early curriculum theorists proved that the principles of science were indeed applicable to curriculum theory.

If the scientific world has provided the foundation on which many seeming "truths" have been grounded, then any major shift in that discipline will invariably have a ripple affect on other elements of society, including the field of curriculum. As knowledge has expanded over time, scientific theories have disintegrated and have given rise to new theories. Once a community accepts a given accumulation of theories and then begins translating reality in light of those theories, the community is said to be functioning under a specific paradigm. Kuhn (1970b, p. 103) defined a paradigm as, ". . . the source of the methods, problem-field, and standard of solution accepted by any mature scientific community at any given time." Capra (1984, p. 22) expanded this definition to include, ". . . the totality of thought, perceptions, and values that forms a particular vision that is the basis of the way society organizes itself." Either definition of paradigm has tremendous meaning for the field of science and society.

Pagels (1988) and Kuhn (1970b) pointed out that paradigms cease to function when the established theories can no longer explain or describe existing universal entities. When a paradigm begins to experience anomalies, scientists will seek to explain their knowledge through various methods (i.e., new mathematical formulas and/or new technology) and thus pioneer new theories. These new theories will not only explain the anomalies, but will also require a reinterpretation of reality. Kuhn (1970b) stated that

> Scientific revolutions are inaugurated by a growing sense . . . that an existing paradigm has ceased to function adequately in the exploration of an aspect of nature to which that paradigm itself had previously led the way (p. 91).

This statement describes what transpired in the field of physics at the beginning of the twentieth century.

The theories resulting from classical science began to break down when scientists of the early 1900's discovered that the elementary elements of classical science could be reduced to their subatomic levels. Scientists soon discovered also that these subatomic elements could not be retained as isolated entities separated from the whole, which had been the foundation of classical science. These discoveries, which came about in piecemeal fashion, marked the beginning of a new paradigm.

Again, if science holds any truth for curriculum, then the scientific principles that emerge out of a new paradigm must be understood in order to understand curriculum. Einstein, Heisenburg, and Bohr have emerged as major contributors to these new scientific theories. Because of their contributions, not only the field of science, but all of society is being forced to redefine reality.

The theories of Einstein, Heisenburg, and Bohr contributed to what has become known as quantum mechanics. However, even though these three scientists could agree on basic scientific principles, the question: "Is there an ultimate reality that exists outside of observation?" caused a major split in the philosophies of these men. The entailing argument, which lasted until Einstein's death, centered around what was known as the Copenhagen Interpretation of Quantum Mechanics.

The foundation of the Copenhagen Interpretation was Heisenburg's principle of uncertainty and Bohr's principle of complimentarity. Out of these two principles, nature was perceived in random terms; consequently,

the behavior of individual parts of nature could only be described through statistics. The real problem in attempting to describe nature was the impact of the observer upon the observed, for if the mere presence of an individual altered motion that was already random, how could science ever expect to fully comprehend the ultimate character of nature? Heisenburg and Bohr's response to this question became the basic tenets of the Copenhagen Interpretation.

Einstein, though a contributor to quantum mechanics, could never accept this interpretation of quantum mechanics. He could not support the principle that nature was totally random and was forever uncomfortable with the indeterminacy that emerged from Bohr and Heisenburg's principles. He was convinced that there must be an underlying objective or cause that worked to interconnect natural phenomena. Therefore, he spent the rest of his life searching for a unifying theory that would restore order to nature.

Regardless of the conflict that erupted over this interpretation of reality, Einstein, Bohr, and Heisenburg contributed to a new way of viewing reality and gave new value to the role of the observer. Pagels (1988, p. 88), in his studies of scientific theories and reality, posed the questions, "Why do we model reality and represent it as a myth, metaphor, or scientific theory?" and "Why does our mind recast its own experience in terms of symbols, symbols whose meaning we often do not understand ourselves?" His response to these questions first centers around the uniqueness of the human species and the ability to create and use various symbols. Secondly, the ability to represent, simulate and describe through the use of symbols, gives individuals the feeling of autonomy over their own experiences. Scientific theories thus become society's way of ordering reality as perceived by our minds and is, to

some degree, reflective of a culture. Apple (1975, p. 123) observed that, "Scientific outlooks have become so ingrained in our consciousness that they have become values, not merely ways of gaining knowledge." If this is true, then one must assume that scientific theories form the bedrock on which a society is built.

When witnessing the disintegration of scientific theories and the rise of new theories, one must question the effect of these changes upon a society. Were Newton and the other scientists of the sixteenth and seventeenth centuries wrong in their theories, therein creating a paradigm that was misleading society? Kuhn (cited in Regis, 1987) was forced to address this same question wherein he developed the concept of "paradigm shock." He began to question the rightness of Aristotle's Physics in terms of twentieth century knowledge. His understanding of Aristotle's work came only after he attempted to view the universe from Aristotle's knowledge base. Kuhn came to realize that Aristotle functioned from a paradigm in which place, purpose, and shape comprised the primary reality. Consequently, working within the given knowledge and with the use of current technology, one cannot say Aristotle was wrong, or that Newton was wrong. According to the definition of "domain of validity," all knowledge can be considered true within the limits of its domain. Therefore, within the confines of their knowledge, these scientists were able to interpret reality. New paradigms thus allow scientists, and consequently society, to redefine reality because of expanded knowledge and, by borrowing the resulting scientific methods, curriculum theorists are able to find alternative ways of dealing with curriculum theory.

Assumption of the Study

To provide a ground work for the current study and to limit the

otherwise boundless directions that study could pursue, the following basic assumptions were made:

1. Language is humankind's way of describing and communicating reality.

2. The field of science has been the primary source of concepts and language that curriculum theorists use in understanding reality.

3. Terminology and concepts used to describe reality, thus become reality.

4. If science has been the foundation for knowledge and understanding of reality, then any major shift in that knowledge and understanding will undoubtedly have an affect upon other elements of society, including curriculum thought.

5. Knowing/learning is no longer viewed as a linear progression built upon previously learned facts in a sequential fashion, but rather must be approached in a wholistic fashion.

Purpose and Organization of the Study

If paradigms are the source of perceptions and values associated with a particular culture, then it follows that the understanding of a particular scientific paradigm could offer insight into a new way of viewing curriculum. Since the Copenhagen Interpretation forced science to reinterpret reality, it is possible that the scientific principles associated with this paradigm could also provide an alternative means for curriculum theorizing. Therefore, the purpose of this study was to investigate the primary components of the Copenhagen Interpretation and then determine their possible relevance for curriculum theory.

Chapter II of this study addresses what has been termed as "classical science," or the "old paradigm." Findings that resulted from

observation and applied logic led scientists of the sixteenth and seventeenth centuries to perceive the universe as a mechanical world or machine that could be reduced to its most elementary parts and then reconstructed in an orderly and predictable fashion. These findings were substantiated mathematically, and were therefore accepted by scientists and the rest of society because they provided acceptable answers to the workings of the universe. The works of Galileo, Descartes, and Newton were reviewed in depth. In an effort to illustrate the affect of classical science upon twentieth century curriculum, a brief comparison was made between the basic principles of classical science and Tyler (1949), whose work with curriculum has become the foundation of most public schools today.

Chapter III deals with the controversy surrounding the Copenhagen Interpretation of Quantum Mechanics. The major leaders in this discussion included Heisenburg and Bohr, who supported the concept of discontinuism (def: once motion is observed, it thus becomes discontinuous), and Einstein, who fully supported the concept of continuous motion. The result of this debate was an admission by scientists that

> A complete understanding of reality was beyond the capacity of rational thought. In other words, physicists could forever mull over ideas about the nature of reality, but would never be able to consider the nature of reality itself (Weaver, 1987, p. 397).

Resultant from this intense discussion was a reality created by observation rather than an existence that followed a hidden order.

Chapter IV of this study focuses on the concept of a changing or emerging reality. If one views reality as being constantly in a state or process, then one must address the elements or components of that reality in order to comprehend its entirety or wholeness. Authors such as Whitehead, Capra, and Whorf identified those components of reality as

experience, perceptions, the mind, and consciousness; therefore, these concepts are discussed in depth. Another extremely important ingredient in the process of an emerging reality is that of the human entity. Jantsch's (1975) work was explored, in which he utilized the perception of an observer and a stream to create a metaphor that demonstrates the role and importance of the human entity in creating reality.

Chapter V addressed the ontological meaning of the Copenhagen Interpretation specifically for schools and curriculum. This section attempted to address the question: "Does an emerging paradigm offer the potential of an alternative conceptual base for reinterpreting the schooling process?"

CHAPTER II

CLASSICAL SCIENCE: ITS FOUNDATION AND AFFECTS UPON CURRICULUM THOUGHT

Introduction

Scientific theories and discoveries before the sixteenth and seventeenth centuries (or before the use of technology) were based upon observation and logic. Because of this method of gathering data, scientists began logically to conclude that the earth was the center of the universe and that celestial bodies such as the moon, sun, and stars followed an elliptical course around the earth. Through the use of common sense, scientists were able to rationalize that the sun must orbit the earth since they observed that the sun rose in the morning and set at nightfall.

This same common sense, which grew out of observation, allowed these scientists/scholars to hypothesize not only the structural content of these heavenly bodies, but also the construct of the entire cosmos. They concluded that stars, which were formed from some imperishable celestial fire, were arrayed throughout the universe. The universe itself was perceived to be a great sphere, which appeared to be smooth and transparent as glass. Since the stars and planets could be observed moving individually, scientists concluded that there must be a series of spheres arranged one inside the other, each capable of supporting its own

heavenly bodies. These conclusions thus provided the foundation on which many scientific theories were built.

Many of the ideas that led to these early theories were derived from the philosophies and concepts of Aristotle, who applied his reasoning powers to nature. These concepts or beliefs were accepted without experimental proof; they appeared to explain accurately the workings of the universe, and were therefore deemed substantiated through observation and logic.

Aristotle's World

Aristotle's teachings established the premise that the earth and the surrounding universe was composed of opposing and irreconcilable realms and also provided insight into the relationship between the human race and nature. This early society came to believe that the purpose of nature was to serve the needs of society, and therefore to help perpetuate their destiny. This concept, belief, or perception was substantiated in Greek philosophy and Judeo-Christian theology and, as a result, filtered into the field of physics. Because these philosophies, which transcended into scientific theories, provided logical explanations that could be visualized (which was the only experimental tool available), they were accepted as truth. Therefore, this knowledge base provided answers for science and society concerning the order and purpose of nature in relation to the needs of human beings.

Galileo (1564-1642)

Galileo was the first to challenge successfully the scientific concepts of Aristotle. Galileo, along with other scientists such as Newton, Kepler, and Descartes, did not abandon the "tools" employed by scientific

predecessors (e.g., observation and logic), but it was through observation and logic (aided by then-new technology) that they began to realize that natural phenomena obeyed or could be explained through mathematical principles. With this realization, scientists began to paint a new picture of nature, the human race, and the relationship that existed between all. This new reality persisted until it too had been challenged by scientists with newer principles of mathematics and more accurate and precise technology.

For example, by employing the principles of geometry, scientists of the sixteenth and seventeenth centuries were able to give new meaning to their observations of the universe. Until the time of Galileo, astronomy was considered to be a branch of mathematics, i.e., of geometry. It was considered the geometry of the heavens, since astronomers could observe a regularity in changing relationships between the point of observation and the heavenly bodies being observed. Because there was no viable opposition to this concept, astronomers concluded that the earth must be a sphere and thus was a reference point from which all other observations were measured. Galileo compared this correlation between geometry and the heavens to a book. He felt that, unless one understood the language and symbols in which the book was written, one could never hope to comprehend its secrets. To Galileo, the language of the universe was mathematical and the symbols were represented as triangles, circles, and other geometrical figures.

Galileo was continually amazed at the correspondence between his observations of the universe and their ability to follow the principles of geometry. Therefore, he felt that it must be mathematics that held the key to understanding nature and the universe, and that logic provided the vehicle for criticism. Logic allowed scientists to determine the

consistency of theories, yet that same logic could not lead to the discovery of those theories. Scientific theories were discovered through the application of mathematics.

As a result of applying mathematical principals to observations, Galileo began to perceive the world, which he espoused as being made by God, as an unchanging mathematical system which could produce absolute certainty of scientific knowledge. This "mathematical system" was perceived as being orderly and simple; every movement was regular and necessary. In a letter written to the Grand Duchess Christina in 1615, Galileo stated that, "Nature is inexorable, acts only through immutable laws which she never transgresses, and cares nothing whether her reasons and methods of operating be or be not understood able by men" (cited in Burtt, 1949, p. 64). Galileo concluded that this orderly and simple universe consisted of mass, motion, and weight, whose interrelatedness could be explained through causal relationships. He further concluded that truth or ultimate knowledge of the universe could only be achieved through mathematical interpretation. Galileo's views of the universe were founded upon visual observation, experimentation, and principles of mathematics.

If Galileo experienced any success in challenging the world as described by Aristotle, it was due to the fact that Galileo's discoveries and theories were not only verifiable mathematically, but were also acceptable to the senses of his peers. He was basically attempting to challenge a reality that made sense to people through logical observation; therefore, it required a logical challenge to be accepted as a legitimate alternative.

Descartes (1596-1650)

Like Galileo, Descartes also contributed to this changing reality by expanding the use of mathematics into physics. Descartes attempted to reduce everything to the rearrangement of particles which moved according to the laws of mechanics. This, in turn, intensified his curiosity about causality or the original source of beings and provided him with another avenue of knowledge to explore. Descartes' insight into causality is best reflected in a statement he made after much pondering and observation, "Cogito ergo cum" ("I think, therefore I am"). Descartes therefore concluded that his own existence was not self-derived, but derived from the ultimate cause of everything: God.

In his search for the ultimate causation of nature, Descartes invented analytical geometry, which allowed him to make two major contributions to this new mathematical reality. First, he developed a hypothesis which explained the mathematical structure and operations of the universe. Second, Descartes attempted to justify the exclusion of humans and their interest from nature. As a result of these mathematical findings, Descartes believed that the world could be divided into two exclusive and exhaustive realms: thought and motion, which became his metaphysical dualism. Given this analysis, it was now up to science to determine or deduce the causes of everything from these two basic principles.

Descartes' use of analytical geometry allowed one to show an exact one-to-one correspondence between the nature of numbers; i.e., space. Even though this relationship was not foreign to the field of mathematics, it was intuition that enabled Descartes to comprehend the absolute correspondence in their relationship. Descartes expanded this concept

and began to believe that this correspondence between nature and mathematics not only applied to the observable world, but would most certainly be applicable to the entire field of physics. This discovery took Descartes back to the question of causality, which once again he felt could be explained mathematically.

In working with the concept of causality, Descartes became the first scientist to explain the solar system in mechanical terms. Mechanical terms meant that the universe consisted of individual parts which were all interrelated through causal relationships and consequently worked in harmony with each other to produce an ordered universe. Descartes saw the individual bodies of the universe as being in various stages of motion which could be defined through mathematical deduction. Thus, according to Descartes, extension and motion (the two basic natures of an object) were mathematically reducible. He further believed that the specific features of extension (dimension, unity, and figure) could be explained through the use of simple arithmetic or geometry. In an effort to explain the onset and continuation of motion, Descartes purported that God set entities into motion and they remained in motion because of the basic nature and will of God. This principle satisfied Descartes' search for the origin of motion and, consequently, made motion just as natural to a body as rest.

Descartes' perceptions of motion and its relationship to extended bodies provided him the framework through which he was able to describe the world as "extended bodies," existing since creation. These assumptions further allowed Descartes to compare the workings of the universe to that of a large machine. In this machine there was no spontaneity at any point; all bodies continued to move in accordance with the principles of extension and motion. Consequently, the universe had to be perceived

as an extended plenum (filled with matter, all of the same kind, and all in motion), and the motion, of whose several parts are connected to each other by immediate impact, all happens with the regularity, precision, and inevitability of a machine. These scientific concepts, espoused by Descartes, described a world that was essentially mechanistic, and since the laws of mechanics corresponded to the laws of nature, entities in nature could be reduced to their elementary parts and reconstructed according to mechanical laws.

Newton (1642-1721)

Kuhn (1970b) stated that scientific theories are many times constructed in piecemeal fashion and an individual theory or finding accredited to one scientist is the summation and/or refinement of many theories. Such is the case with Newton. Newton was able to build upon the works of Galileo and Descartes, and draw conclusions that expanded and broadened their earlier findings dealing with the nature of the universe.

Like Descartes, Newton was very intrigued by the concept of motion. In his book, Principia (vol. I), Newton outlined three axioms or laws of motion which have maintained credibility through the twentieth century:

1. Every body continues in its state of rest, or of uniform motion in a right light, unless it is compelled to change that state by forces impressed upon it.

2. The change of motion is proportional to the motive force impressed, and is made in the direction of the right line in which the force is pressed.

3. To every thing there is always opposed and equal reaction (p. 13).

The third law of motion allowed Newton to demonstrate the equality of action and reaction. To test this concept, Newton suspended two balls

and then attempted to measure the results of their collisions. He discovered that upon impact, the effect upon each ball was an equivalent amount; thus, the action and reaction were equal. Newton further concluded that laws applying to greater motion must also hold true for lesser motions. For example, if heavenly bodies are controlled by the forces of larger bodies; then consequently, bodies of lesser motions should also be controlled by lesser forces. As a result of these two principles, Newton was able to establish a sense of continuity and order, both to heavenly motion and earthly motion.

Another area in which Newton had tremendous insight was in the area of time and space. According to Newton's theories, space was not objective (as perceived by Aristotle), but was dependent upon the observer's motion. What was the objective element in reality was "time space." Newton was very much aware that space and time could not have completely separate identities because there was no way to indicate meaningfully a change in time at any point in space. Observers moving separately would not only have different coordinates assigned to a given point in space, they would not even be able to agree on the identity point in space. Because Newton assumed that space was "flat," he was able to explain the concept of relative space-time through Euclidean geometry (plane geometry).

Newton was not only interested in motion and relative time space; he also showed significant interest in the concept of causality. Earlier, Descartes had explained that the self-derived existence of God was being the ultimate cause of all things. Newton, however, began to expand this ideal, and even though he utilized causal language, he introduced an important qualification: the cause of certain entities is not derived from a power or "excellence," but rather is derived from the uniqueness

of their nature. Newton differed from Descartes in that Newton did not believe that God was literally the cause of himself or that valleys were the result of mountains, but rather, these entities existed because it was characteristic of their nature to exist. As summarized by Newton, "An immediate cause and effect must be in the same time and therefore, the preexistence of a thing can be no cause of its past existence (also because the after time does not depend on the former time") (cited in McGuire and Tamny, 1983, p. 138). Newton, while working with the principle of causality, identified the principle of uniformity. This new principle stated that in determining a natural effect, one must identify the same cause. Consequently, Newton removed the ultimate cause of entities from a supreme being or outside force and postulated that entities, including a supreme being, existed as a result of natural characteristics. He also was able to show consistency in causal relationships by declaring that identical effects must be a product of the same cause.

The linchpin of Newton's insights into motion, time space, and causality was the use of a precise language which described mathematical relationships. This description made possible the systematic analysis of motion and the ability to predict future behavior of all celestial bodies. Through this mathematical approach, Newton was able to explain not only the orbits of planets, but also the irregular motion of the moon, the paths of comets, and the ebb and flow of the tides. In an effort to explain and fully comprehend these natural phenomena, he began comparing the universe to a very large watchspring which had been wound up by God and then left to "run down" systematically on its own. Assuming that the universe did follow orderly (and therefore predictable) laws, it became the task of Newton to discover these laws, or at least provide the construct from which to explain the workings of the universe.

Newton's laws of nature not only served his generation, but gave insight into future scientific theories. For example, he anticipated the concept of transformation, which is the idea that particles can be created and destroyed. This concept was also an expansion of Descartes' earlier findings whereby he attempted mathematically to reduce bodies down to their rearrangements of particles. Newton, however, while exploring the principles of light, began to realize that light could be made to disappear; thus, instead of particles becoming rearranged they merely vanished. Also, while working with light, Newton questioned whether light was a particle or a wave. Though two centuries before the advent of quantum mechanics, he eventually embraced the particle theory, even though his findings concerning light were the foundations of the wave theory.

Newton's theories revolutionized the field of science. It was through his theories that the scientific community was able to understand not only the universe but also the world that surrounded them. This newfound knowledge allowed scientists to perceive an existing order and unity in both spheres of reality. Because of the methods used by Newton to develop his theories, he ushered in the Age of Reason. Scholars now expected to be able to solve most problems by accepting a few axioms which had been worked out through observations and then carefully substantiated and explained through mathematical principles.

Summary of Classical Science

The reality described by Galileo, Descartes, and Newton was much different from that which had been seen by Aristotle. Aristotle saw a universe whose every movement was controlled by supernatural beings. Humankind was the center of this universe and was held in such esteem

that the functions of the universe were there to serve the human race. Even though Galileo, Descartes, and Newton described a different reality, this is not to say that Aristotle was wrong in his basic principles; he is a celebrated and very respected scholar. However, given the "tools" of the period (observation and logic), one can at least understand the rationale behind his subsequently disproven conclusions, which appeared very accurate and thus able to answer satisfactorily questions concerning the universe.

However, tools become antiquated as newer tools are developed, which allow scientists/scholars to draw more accurate or different conclusions. Such was the case with the new generation of scientists. They did not put aside the "old" tools of Aristotle, for Galileo, Descartes, and Newton all observed and came to logical conclusions, but their data were the results of not only the "older" tools of logic and empirical knowledge, but also the newer and more precise tools such as geometry and calculus. Thus, the reality seen by these scholars was very different than that seen by Aristotle.

With the discovery that mathematical principles of the time (Euclidian geometry) could be applied to the workings of the universe, both celestial and terrestrial, scientists were now beginning to have an understanding of the workings of the cosmos. They were now able to expand their understanding of motion and original causation and, as a result, gain a clearer understanding of these observable and predictable phenomena. The fact that scientists could now mathematically predict planetary movement forced them to question or reevaluate the role of God. Though never questioning the existence of God or a supreme power, Newton redefined the function of God. Instead of God being in direct control of every specific movement of the universe, Newton maintained that once

heavenly bodies were set into motion, God then allowed them to "run down," or function, on their own power; thus, the universe was predictable and consistent (like the workings of a machine or of a great clock). Descartes contributed to this new understanding with his statement of the vortex theory. Through this theory, Descartes was able to explain planetary orbits which, in turn, regulated God to the position of the perpetuator of motion. Given the origin of motion, the natural happenings of the universe then continued in regular revolutions as found in a mechanical machine. The term or concept of "clock" to these scientists summoned up the image of a great cathedral clock. These massive clocks were powered by their descending weights, thus moving the hands which turned by their axles. Not only did the term "clock" refer to this enormous time piece, but also to everything associated with it.

> Mechanical men rang bells. Saints appeared through the doors. Cocks crowed to tell the hour. One complex mechanism generated a multiplicity of operations that suggested the infinite phenomena of the infinitely complex machine we call nature, except that the cosmic clock made by the divine watchmaker required no winding up. The conservation of the total quantity of motion, and principles of inertia on which it rested, insured its eternal operation (Westfall, 1980, p. 15).

This new generation of scientists brought a sense of order to the universe. An order that was mathematical, accurate, and precise. That is not to say that science had all of the answers to the workings of the universe. Though Newton and Descartes disagreed on many areas, both sought answers to the same questions. Bernard le Bovier de Fontenello (a French writer and amateur scientist) stated, upon the death of Newton, "[Descartes] set out from what he knew clearly in order to find the cause of what he saw. The other [Newton] set out from what he saw in order to find the cause" (cited in Crombie, 1959, p. 166). Even though Galileo, Descartes, and Newton used various methodologies and took differing

points of view concerning reality, these scientists of the sixteenth and seventeenth centuries answered enough questions with a good deal of accuracy to bring credibility to their reality. This reality or world was a

> . . . quantitative world instead of the qualitative world of daily experience, mechanistic instead of organic, indefinite in extent instead of finite, an alien world frightening to many but in its challenge, thrilling to some (Westfall, 1980, p. 1).

This new reality thus required a new language that could adequately describe what was transpiring in nature. With geometry, algebra, and calculus forming the foundation of this revolutionary knowledge, reality could now be described in terms of causality, reduction, precision, and predictability.

Galileo, Descartes, and Newton were on the cutting edge of a new paradigm. In the study of paradigms, Kuhn (1970b) stated that

> Scientific revolutions are inaugurated by a growing sense . . . that an existing paradigm has ceased to function adequately in the exploration of an aspect of nature to which that paradigm itself had previously led the way (p. 91).

The anomalies that arose from the old paradigm (Aristotle's theories) gave these scientists the opportunity to explore new knowledge and the technological advancements of the period, coupled with the new mathematical tools, provided the vehicle for the exploration.

Classical Science: Foundation of the Tyler Model

When Aristotle's theories could no longer serve their purpose for society, science then was forced to seek new theories which did provide viable answers to questions concerning the universe. Such was the case in education at the beginning of the twentieth century. The educational system could no longer meet the demand to educate the large populace of students entering the schools as a result of immigration. Therefore, alternative methods were required if schools were to accommodate the

special needs of immigrant children, and yet maintain a high level of education for other students. As stated in Chapter I, Huxley, Spencer, Bobbitt, and Charters authored reforms that not only made schools more efficient, but also modernized the curriculum to meet the needs of a twentieth century society.

Both Bobbitt and Charters taught at the University of Chicago while Ralph Tyler was attending graduate school, and when considering that Tyler was the graduate assistant of Charters, it is little wonder that one can see the influence of both of these men in the works of Tyler. In Tyler's (1949) book, Basic Principles of Curriculum and Instruction, he outlined steps in developing curriculum that, over time, have become so accepted in education that they have, ". . . been raised almost to the status of revered doctrine" (Kliebard, 1975, p. 70).

Tyler (1949) felt that the foundation of curriculum should be built around four basic questions:

1. What educational purposes should the school seek to attain?
2. What educational experiences can be provided that are likely to attain these purposes?
3. How can these educational purposes be effectively organized?
4. How can we determine whether these purposes are being attained? (pp. 1-2).

In summary, the Tyler model consisted of stated objectives, selecting specific activities that led students through organized experiences and then provided evaluation as to the successful completion of the objectives.

First, in developing objectives, one draws from the learner, society, and subject matter. In addressing the learner, one acquires data through the use of interviews, observations, tests, and questionnaires.

Like Bobbitt, Tyler (1949) felt that society should be divided into specific categories such as religion, vocation, recreation, etc., and then objectives should be developed that are relevant to each. Objectives dealing with subject matter are based on required content and skill. Once the objectives are identified, Tyler suggested that they be screened, based on a philosophical and psychological criteria.

Second, once the lists of objectives have been prioritized, learning experiences need to be developed which will provide interaction for the student and will ultimately enable the student to achieve the stated objectives. Tyler (1949) identified this interaction as being between the students and their environments; however, the teachers have the ability to control those environments such that the objective can be met.

Third, once the activities or experiences have been determined, they must be organized so that the student is able to achieve the specified objective. Tyler (1949) suggested three categories for organization:

1. Continuity--vertical reiteration or recurring opportunities to learn various skills,
2. Sequence--exposure to experiences that build upon each other,
3. Integration--the relationship among different subjects in curriculum (pp. 84-85).

Once these have been accomplished, then fourth, there must be some form of evaluation. This requires that the objectives be written to include both a content component and a behavioral component that can be observed and evaluated. Evaluation is accomplished through tests, observation, interviews, questionnaires, and actual student products.

In applying this model to the student, Tyler (1949) suggested that students need some sort of initial analysis to determine their present status. Once this is determined, the outcome should be compared to the

accepted norm to determine deficiencies. After it is determined where the students are deficient, the model can be applied to help them achieve the acceptable norm. According to Tyler, "The real objective of education is to bring about significant changes in the student's patterns of behavior" (p. 44). Therefore, Tyler saw objectives, not as specific habits that students acquire, but rather as, ". . . modes of reaction to be developed" (p. 43). This change in behavior is accomplished by determining deficiencies, providing specific opportunities for interaction, and evaluating to determine the success in remediating the student's behavior.

The Tyler model has since become the foundation of most schools today, whether it be a conscious use of the model or an unconscious use. Schools are built around stated objectives, whether it be at the state level, local level, or in daily lesson plans. The learning process is broken down into segregated parts to which the phrase "scope and sequence" is now applied. Learning is the result of building onto previously learned concepts in a piecemeal fashion and thus becomes a linear process. Once a student has progressed through this maze of predetermined objectives at a certain level of proficiency, they are then deemed educated.

Conclusion

When reviewing the concepts of the Tyler model, one is able to see the correlation between the components of Tyler's model for curriculum and the basic principles of classical science. Galileo, Descartes, and Newton sought to understand the order of the universe through a reductionist frame of reference. By utilizing that same reductionist concept, Tyler sought to reduce curriculum to its most elementary parts, and then

to construct the educational process in building block fashion. Tyler, through explicit objectives and experiences, attempted to order curriculum such that the learning experience became orderly, predictable, and deterministic. While mathematics provided the language of classical science, so too does mathematics provide a language for determining success of students in achieving the stated objectives of curriculum. Evaluation of a student's success in meeting stated curriculum goals, most typically, is through testing. The test results thus provide a mathematical description of a student's success in learning. Just as classical science provided for no direct relation between humans and their universe, Tyler excluded the learner from curriculum. Curriculum was a separate entity to be acquired by the student. Consequently, the reality described in Tyler's curriculum model is objective, contains causal relationships, and is therefore deterministic. It is very reflective of the "classical" scientific paradigm that saturated not only the scientific community, but also curriculum theory.

CHAPTER III

THE COPENHAGEN INTERPRETATION

Introduction

Because scientists of the sixteenth and seventeenth centuries were able to extend their observations and experiments due to technology and advanced mathematics, they were forced to develop new methods and rewrite scientific theories that reflected the reality they were now capable of observing. These same theories and methods were, in turn, challenged as a new generation of scientists expanded upon this knowledge through more sophisticated technology. As a result of this technology, scientists were now able to deal with occurrences at the atomic and subatomic levels. Thus, quantum mechanics grew from the ability to observe the finite elements of nature's phenomena. With the onset of the twentieth century, science once again found itself in the midst of uncovering a new interpretation of reality. This new interpretation (known as the Copenhagen Interpretation of quantum mechanics) presented new avenues of knowledge to explore which required new scientific methods to comprehend the unfolding reality.

A Brief History of Quantum Mechanics

Three landmark findings marked the beginning of what has become known as quantum mechanics. They include the discovery of discontinuous motion, the law of radioactive disintegration, and the discovery of the

wave-particle duality. All three discoveries originated from an attempt by scientists to understand the properties of light.

The first landmark discovery came in 1889, when Professor Max Planck of Berlin published findings from his work dealing with radiation. He was able to prove that motion associated with nature was discontinuous, rather than continuous, as found in classical science. It was the belief in continuous motion that had allowed Newton to develop his three laws of motion, and according to Newton, not only was motion continuous but entities interacted with each other. Consequently, each interaction caused their motion to either accelerate or change direction. These findings thus found motion in a continuous state and constituted the principle of causality, which was defined as the belief that for every effect there must be a logical cause.

Planck's (1987) findings not only challenged the principle of causality, they also made two other significant contributions to science. First, he was able to explain what had fascinated scientists before him; namely, the behavior of light. Planck demonstrated mathematically that light waves did not travel in continuous motion, but rather propagated in discontinuous motion. Second, he made his explanation of light behavior through a mathematical formula which could not be visualized. This lack of visualization introduced a new era into the scientific community. No longer could science rely upon observation for verification of experiments, but now was forced to depend upon intuition and the blind acceptance of mathematical findings. Because the principle of discontinuous motion radically altered scientific principles, scientists such as Bohr began exploring the ramifications of this new concept.

Bohr (1987) expanded Planck's concept of discontinuity by applying it to electrons, which at this time were the ultimate particle. Bohr

compared the movement of electrons, not to a train which moved smoothly and "continuously" on track, but rather to kangaroos hopping about in a field. This comparison to kangaroos illustrated the spontaneous and discontinuity of motion that Bohr felt was characteristic of electrons. Thus, science began to comprehend the motion of particles. This new knowledge not only opened up new areas for scientists to explore, it also began to chip away at the foundation of classical science.

Like Planck, Rutherford and Soddy (1987) also challenged the principle of causality with the second landmark discovery. In 1903, Rutherford and Soddy presented the fundamental law of radioactive disintegration. According to this law, atoms of radioactive substances split spontaneously and not as the result of any particular happening or condition. This discovery completed the destruction of the laws of causality by demonstrating that there was no apparent "cause" for radioactive break up.

In 1917, Einstein presented the third major landmark discovery, which would eventually win him a Nobel Prize in 1921. Through a theoretical investigation, Einstein attempted to connect Planck's findings of discontinuous motion with Rutherford and Soddy's law of radioactive disintegration. He showed that the laws that governed the disintegration of radioactive substances also governed the spontaneous jumps of kangaroos that Bohr had earlier described. These laws were of the simplest statistical form. They showed that, out of any number of kangaroos, a certain percentage would jump within a given time, yet there was nothing observable to determine the kangaroos that were about to jump from those that were not. The only explanation that could be derived was that the jumps were in accordance with statistical law. This statistical concept thus opened the door for Einstein to comprehend the nature of light.

Through his findings, Einstein proposed that light consisted not of light waves (as had been determined in 1860 by Maxwell), but of energy particles. This concept supplied the answer to what medium was present for light to travel on if space did not contain particles of ether on which light could travel. This answer had eluded scientists since the determination had been made that space was empty and that light could be seen in a vacuum. This finding, however, presented a paradox to scientists. Waves and particles now seemed to be independent entities, yet light appeared to assume both characteristics, depending upon the experiment. Scientists had thus discovered the wave-particle duality of nature and, as the wave-particle duality began to emerge into the field of physics, so too did the concept of discontinuity. Jeans (1946, p. 127) stated that, "As discontinuity marched into the world of phenomena through one door, causality walked out through another."

These new scientific concepts were a dramatic break with classical physics. Quantum mechanics not only changed the laws of physics, but also altered the focus of scientific questions. Where classical science had provided the ability to predict future behavior, quantum mechanics could only provide statistical probabilities because of the unpredictable characteristic of nature. Quantum mechanics (theory) can be summarized as a method through which scientists can predict probabilities that measurements of specified kinds will produce certain responses in given situations. Because of the ambiguities associated with quantum mechanics, some scientists prefer to regard it more as a set of rules that are used to identify the outcome of experiments. Regardless of its use, quantum mechanics presented a totally new way of looking at nature; consequently, the scientists involved with quantum mechanics were on the cutting edge of a new era (paradigm) in science.

Bohr and Heisenburg were two such scientists, whose discoveries and methods have since been considered the foundation of quantum mechanics. Their contributions came about as a result of expanding and refining the earlier concepts dealing with motion of subatomic particles. Their resulting theories (Bohr's Principle of Complimentarity and Heisenburg's Principle of Uncertainty) forced scientists to reevaluate the total concept of reality. Bohr and Heisenburg's interpretation of reality spurred an argument between scientists that lasted for many years and still continues to hold room for discussion.

Bohr's Principle of Complimentarity

The wave-particle duality of nature intrigued scientists and the knowledge gained from their experiments eventually led to Bohr's theory on complimentarity. In 1924, Prince Louis de Broglie (cited in Boorse, Motz, and Weaver, 1989) showed that electrons possess wave particles which can be described in terms of wave lengths and frequencies related to their momenta. Schroedinger (1987), taking de Broglie's wave nature of particles, believed that if it was possible to describe the propagation of light by a wave equation, then one must be able to describe a wave pattern by a wave equation. This equation made it possible to trace the motion of particles with a limited degree of accuracy. Born (1987) continued by showing that the waves associated with a particle must be interpreted as a statement of probability for finding a particle in a given space at a given time. Consequently, the particles appear to behave not only as a wave, but also as a particle. This "wave-particle" duality was now part of quantum mechanics, and was a result of the continuity-discontinuity duality. The concept of duality presented the opportunity for Bohr to explore the idea of complimentarity.

Bohr first introduced the term "complimentarity" in 1927, when he referred to the complimentary relationships that exist between spatio-temporal descriptions and causality. Bohr's principle of complimentarity suggested that protons, electrons, and other "particles" could exhibit both wave and particle properties. These two properties, however, could not exist simultaneously. Therefore, to gain a complete understanding of the whole entity, it required that both properties be considered.

Bohr (1958) explained this duality of nature by stating that evidence obtained under various experimental conditions could not be understood within the frames of a single picture, but could only be regarded as complimentary, in that the totality of a phenomenon goes beyond the data obtained in a given experiment. When compared to classical science, Bohr (1963) explained that classical science allowed one to understand or comprehend the total nature of an object through experimentation, whether it be one experiment or several experiments whose results supplemented each other. As a result of complimentarity, scientists were now being forced to accept that observations could only provide a partial view of an entity rather than a complete picture as could be had through classical methods.

This wave-particle duality became part of a new paradigm in science. However, as typical in a period of changing paradigms, Bohr found himself dealing with concepts of the old classical paradigm. First, the individual entities ("wave" and "particles") both were carryovers from classical science and therefore brought with them specific concepts as to their nature, as defined by classical theories. Bohr found, however, that when these concepts were applied to quantum physics, their reactions were not the same as when applied to classical physics. Second, Bohr was seeking to determine what caused one or the other characteristic to appear. This

question of causality directly reflected classical methods, yet when speaking in terms of relative space-time, it thus became exclusive of classical mechanics. To reconcile these two scientific worlds, Bohr (1963) concluded that the meaning of a concept was dependent upon the conceptual framework from which it functioned. Therefore, given a new conceptual framework from which to view nature, Bohr was beginning to detect an element of randomness in nature.

Heisenburg's Principle of Uncertainty

Another theory which also confirmed the random characteristic of nature was Heisenburg's Principle of Uncertainty. Like Bohr, Heisenburg was also attempting to understand motion associated with atomic particles. He continually argued that one should abandon the use of models, which had been consistently used by scientists to explain scientific theories, and rely solely upon mathematics. Therefore, Heisenburg was perplexed as to why he could not calculate something as simple as the trajectory of an electron in a cloud chamber.

While pondering this question, Heisenburg (1958) began to contemplate a statement made earlier by Einstein regarding the relevance of scientific theory. Einstein proposed that scientific theory ultimately determines what is observed by scientists. Heisenburg therefore began to question if nature only revealed situations that could be explained through the mathematics of quantum mechanics. However, he concluded that on the very small scale of the atom, there must be limits as to the extent that an event can be known. Therefore, if the position of a particle can be determined, one must lose information as to the velocity of the particle. Conversely, if one is able to determine the velocity, then

as a consequence of measurement, information pertaining to its position is lost.

Scientists found that they could not control quantum reactions (the indivisible unit in which waves may be emitted or absorbed) when attempting to measure or observe atomic motion. Therefore, once a new element (such as a measuring device) is introduced into the atomic world, the device alters the motion and position of the particles. Consequently, the more accurate the measurement of either position or velocity, the less accurate the information will be on the other. Heisenburg (1958) found that knowledge of position is complimentary to knowledge of momentum. Therefore, to know one with high accuracy requires that the other cannot be known with any degree of accuracy. However, both position and momentum must be determined if one is to understand the behavior of a system. As summarized by Heisenburg (1987, p. 365), "The exact knowledge of one variable can exclude the exact knowledge of another." This ambiguity of nature thus forced Heisenburg to seek an answer through mathematics that would explain this uncertain knowledge.

In time, Heisenburg was able to explain this concept of uncertainty through mathematics which produced statistical outcomes, and emerged in 1927 with the principle of uncertainty. This principle marked the end of determinism in science. No longer could science hope to gain complete knowledge about an individual particle; consequently, predictions concerning future behavior became impossible. The only prediction that science could now make would be statistical in that scientists could only predict the probability of a particle's velocity or position. However, determinism was not the only theory of classical science to be challenged by the uncertainty principle. This principle also marked the end of absolute truth which had been a pillar of classical science. While

Newton, Galileo, and Descartes could gather information that allowed them to describe and understand whole entities, now scientists were being forced to accept trade-offs in knowledge concerning the subatomic world.

Not only were scientists having to accept the idea of limited knowledge, they also were being forced to deal with impact of the observer upon the observed. If the knowledge acquired in an experiment is affected by the observer, then scientists began to question the role of the observer in determining reality. This concept eventually led to a paradox that still provides the following topics for discussion:

1. Is reality subjective or objective?

2. Is there a reality present outside of one's ability to observe, or does the act of observation determine the characteristics of reality?

The Copenhagen Interpretation provided a view of quantum mechanics which attempted to answer these fundamental questions of science. Though this interpretation resulted in a major division in the scientific world and still provides questions to be answered, it has emerged as the most accepted interpretation, to date, of reality.

The Copenhagen Interpretation of Quantum Mechanics

The Principle of Complimentarity and the Principle of Uncertainty provided the framework for the Copenhagen Interpretation of Quantum Mechanics. This interpretation rejected the idea that nature could be understood simply by comprehending the existence of entities in both space and time. Even though no formal doctrine was ever presented as such, the Copenhagen Interpretation has received much acclaim for its ability to explain natural phenomenon.

The Copenhagen Interpretation represented an admission by scientists who attended the Fifth Solvay Congress in 1927 (Einstein, Bohr, Planck,

de Broglie, Schroedinger, Born, Larentz, Kramers, Pauli, Dirac, and Heisenburg) that one could not completely understand reality through the use of rational logic. These scientists began to believe that one could never fully comprehend the nature of reality itself, but only consider ideas about the nature of reality.

The scientists at the Fifth Solvay Congress started to ponder the ramification of Heisenburg's uncertainty principle which had produced the probability function. These scientists realized that a probability function could not describe a specific event, but rather describes a continuum of possible events until a measurement is taken, thus interfering with the system, and a single event is identified. Heisenburg (1958) best described this phenomenon by explaining that "classical" science begins by measuring the position and velocity of the planet being studied. The results of the observation are translated into mathematics by identifying the numbers for the coordinates and the momenta of the planet. The mathematical equations thus allows an astronomer to predict the properties of the system at a later date. However, in quantum theory, if one is attempting to determine the motion of an electron through a cloud chamber and can determine the initial position and velocity of the electron, the information gathered will not be completely accurate, for it will be impossible to determine both the position and velocity of the electron with any degree of accuracy. Due to the quantum nature of these electrons, if one attempts to determine the position of the electron, the velocity is altered as the electron collides with the measuring instrument. Conversely, as one attempts to measure the velocity, the mere presence of the measuring device will alter the position of the electron, thus providing inaccurate information.

Heisenburg (1958) further pointed out that the inaccuracies stemming from the uncertainty relations allow scientists to translate the conclusions of their observations into the mathematical formulas associated with quantum theory. The probability function associated with this type of experiment represents two components which are, in turn, interrelated. It first represents a fact in that it assigns an initial probability time to the given situation, meaning that the observed electron is moving at an identifiable velocity at a given position. One must understand that "observed" is limited to the accuracy of the experiment.

The second component is that of knowledge, defined as the recognition that another observer could possibly have more accurate information concerning the position of the electron. Heisenburg stressed that errors associated with an experiment are not associated with the electron itself, but rather represent a deficiency in knowledge about the electron. The knowledge concerning the position of an entity is complimentary to the knowledge about its velocity. The more information one has concerning either property (position or velocity), the less accurate one becomes in calculating the other property. Yet, neither property can be excluded if the observer is to determine the behavior of the total system. Heisenburg came to the conclusion that the space-time description was complimentary to the deterministic description of an atomic event.

By introducing the idea of complimentarity into quantum mechanics, Bohr had succeeded not only in showing the individuality of quantum phenomena, but also in identifying the unique features associated with the problems of observation. The individuality associated with quantum mechanics is witnessed by the fact that every reduction of a phenomenon will require altering the experiment. This reduction results in creating further possibility for interaction between the object and measuring

instrument. This concept then leads to the next topic introduced by Bohr, that being the effect of observation on the subject.

It was determined that the act of observation cements a description into a specific space and time and, consequently, breaks down the continuity of the system, thus altering one's knowledge of the system. Bohr (1963) pointed out that "classical" science allowed the observer to neglect the interaction between the object and measuring instrument, and if not totally neglected, at least compensated for in the final calculations. However, in quantum mechanics, one must account for all relevant features that comprise the experiment because of quantum reaction and interaction.

The concepts of probability, uncertainty, and the active role of the observer all provided the framework of the Copenhagen Interpretation. However, there are two key ingredients to the Copenhagen Interpretation. First is the concept that quantum theory contains nothing that can be perceived as descriptions of qualities of nature which might be located at a specific point or immeasurably minute region in space and time. These descriptions are more like abstract symbolic devices that allow scientists to predict what will be observed in given situations. One must remember that the descriptions are more for utility purposes rather than descriptions of properties or qualities. Bohr (1958) observed that quantum mechanics provides a tool for complimentary description in that quantum mechanics is a symbolic method of making predictions.

The second ingredient is the assumption that quantum theory provides a complete scientific account of atomic phenomenon. Bohr (1963) concluded that quantum mechanics deals with the wholeness of entities and phenomenon, and even though outcomes of experiments are statistical in nature, they allow for the interaction of the object and measuring

apparatus. Therefore, the statistical representation of that interaction reflects the occurrence of individual quantum effects in any experimental arrangement.

This interpretation of quantum mechanics not only required scientists to admit to a reality that could not be visualized, but also one that depended upon a statistical interpretation rather than a reality that could be comprehended through exact mathematical formulas. This interpretation also required that the observer be recognized as an important element in the creation of a specific reality. Bohr and Heisenburg were able to show that once an observation (measurement) was made, the motion of that object was disrupted and thus frozen in time. This discovery had far-reaching ramifications. For example, reality henceforth was to be considered in terms of wholeness, which included not only the observed but also the observer, plus the measuring instrument. Also, instead of describing one's findings in terms of specific qualities, findings must be described in terms of relationships and probabilities. This interpretation of quantum mechanics thus destroyed the possibility of the existence of an independent reality that was open to investigation and held together by elements of causality.

Einstein was present at the Fifth Solvay Conference (1927) when this interpretation of quantum mechanics was discussed, and even though he had contributed to the creation of quantum mechanics, he had great difficulty accepting this interpretation of it. What concerned Einstein most was the probabilistic or statistical requirement of quantum mechanics. He could not accept that there was no underlying deterministic theory to support quantum mechanics. Just as classical science was held together by classical mechanics, Einstein felt sure that there must be an underlying force that explained atomic reality. He was never convinced that

quantum mechanics could give one a complete description of nature, and for the next several years attempted to disprove the Copenhagen Interpretation of quantum mechanics.

Einstein's Theory of Relativity

Einstein's argument against the Copenhagen Interpretation was founded upon one of his earlier discoveries, the Theory of Relativity. This theory resulted from Einstein's attempt to measure heavenly motion. When Maxwell, in 1860, discovered that light traveled through a vacuum, he also discovered that space did not consist of particles of ether. The elimination of ether removed the frame of reference that was required as a basis of measurement; thus, Einstein set out to find a replacement frame of reference.

Einstein (1923) made two assumptions concerning motion and measurement that provided the foundation of the Special Theory of Relativity which emerged in 1905. First, when one discovers the correct laws of physics, those laws will obey the primary laws of Galilean relativity: the laws will exhibit exactly the same forms in all uniformly moving, "inertial," reference frames. The second postulate asserts that the observed speed of light will be the same for any inertial frame.

Einstein asserted that the Special Theory of Relativity did not deviate from classical science through the postulate of relativity, but rather through the consistency of the velocity of light which, when combined with the special principle of relativity, produced the relativity of simultaneity. Where classical science allowed for uniform measurement, Einstein was finding that measurement was relative, depending upon one's frame of reference; however, scientific laws should be the same for all freely moving observers.

The concept of relativity radically modified scientists' concepts of space and time. As a result of this new finding, space, time, mass, and eventually simultaneity, all became accepted as relative properties. To illustrate the ramification of this concept, consider two events, such as snapping the fingers of both your hands with outstretched arms. Each event will have two separate sets of space and time values for any observer. Classical science easily assumed that these two events were either simultaneous or not simultaneous. However, in special relativity, simultaneity is dependent upon the reference frame. A person in a spaceship moving parallel to the outstretched arms will not witness the same snap of the fingers as would be observed from someone stationary on the earth. Consequently, if simultaneity no longer could be considered an absolute property, then it appeared that the universe had no verifiable reality. There were no universal moments and the present was only verifiable relative to each observer.

The concept of relativity began to change scientists' perceptions of the world. Newton had introduced the world to absolute time and space, and now Einstein, through his Theory of Relativity, began to redefine space and time and created a universe that consisted of separate space, separate time, and separate objects. The loss of absolute space and time allowed scientists to now consider that entities such as space, time, mass, electricity, etc., could potentially interact with each other, rather than being perceived as independent entities, resulting from their formerly absolute status.

The potential interrelatedness of space and time required a new type of mathematics. When classical scientists had looked at the space around them, they perceived it as consisting of small points which go together to make lines which, in turn, create planes. Scientists were now being

forced to deal with the possibility that the space around them might not be Euclidean. Space, which had been three-dimensional (length, breadth, and thickness), now merged with time and thus required four numbers to describe space-time. In four-dimensional geometry, motions that describe inertial systems are characterized by straight lines (called world lines); however, in systems that are accelerated, these world lines become curved. Thus, the concepts "straight" and "curved" become relative, in that they refer to orbits of the light rays and of freely moving bodies. This principle destroys the structure of Euclidian geometry, because the foundation of Euclidian geometry was the classical law of inertia, which derives straight lines. This became the foundation for Einstein's General Theory of Relativity. Hawking (1988, p. 184) explained that the General Theory of Relativity is, ". . . based on the idea that the laws of science should be the same for all observers, no matter how they are moving. It explains the force of gravity in terms of the curvature of a four-dimensional space-time."

Einstein (1923) believed that the true geometry of the space-time continuum is non-Euclidean, or curved. He believed that the mere existence of mass distorted space so that the shortest path between points was no longer a straight line, but rather curved on a curved surface. Motion of these masses was determined, not by a distant gravitational force as understood by Newton, but rather by the warped field of space-time which he mathematically deduced as being finite, but having no boundaries. For example, under classical science a traveler on a sphere could keep walking indefinitely in any one direction, and would always return to the original starting point. Einstein, however, believed that the world was not shaped by Euclidean geometry consisting of parallel and perpendicular lines which acted mechanically, but rather was shaped by

masses and their velocities. This belief formed the framework of Einstein's theories of relativity.

Through his Theory of Relativity, Einstein was not attempting to say that everything is relative as some have interpreted; in fact, he considered naming this theory the Invariance Theory. Einstein was able to discover, however, what was absolute despite the illusions and contradictions presented by nature. The primary merit of the term "relativity" is the concept that a scientist is unavoidably part of the system that is being studied. Therefore, Einstein gave new value to the role of the observer in science. Einstein was confident that an absolute truth did exist. Through the Theory of Relativity, he provided for the reconciliation of various observers' views in relationship to their velocity in their particular space-time forms.

Einstein's Response to the Copenhagen Interpretation

Einstein's background in the study of relativity could not allow him to accept the Copenhagen Interpretation. Einstein's basic argument can be summarized into three main points:

1. It is not proven that the usual concept of reality is unworkable.
2. Quantum theory does not make 'intelligible' what is sensorily given.
3. If there is a more complete thinkable description of nature, then the formulation of the universal laws should involve their use (cited in Stapp, 1972, p. 1109).

Einstein set forth to prove that there was an independent reality that existed apart from, and independent of, our sense reality. Over the next several years, he proposed to Bohr several thought experiments in an effort to disprove Bohr's interpretation; however, in each instance Bohr

was able to refute the experiment. Einstein could not accept Bohr's theory even though he had to concede to Bohr's logic.

In 1935, Einstein, along with Podolsky and Rosen, presented a paper entitled, "Can Quantum-Mechanical Description of Physical Reality be Considered Complete?" (more commonly known as the "EPR paper"). This paper became Einstein's most profound attack on the concepts of quantum theory. In this paper, the authors attempted to show that the quantum mechanical description of nature could only provide an incomplete picture of reality. It focused on the belief that physical properties have no objective reality outside of the act of observation. Einstein felt confident that "things" did possess specific properties independent of their measurement. The foundation of the EPR argument rests upon the statement that, "If without any way disturbing a system we can predict with certainty . . . the value of a physical quantity, then there exists an element of physical reality corresponding to this physical quantity" (Einstein, Podolsky, and Rosen, 1935, p. 777).

In the EPR paper, Einstein, Podolsky, and Rosen (1935) presented a thought experiment to disprove the principles of the Copenhagen Interpretation. The situation created two space-time regions that were so far apart that the act of measurement in one space-time region could not affect the second space-time region by any known dynamical mechanisms. Within these two space-time regions, the authors stated, if one can ascertain the motion of one particle, then one can determine the affects of that motion on a second particle without introducing the act of measurement. For example, if the spin of one particle accelerates, then the spin of another particle decelerates. Does this not lead one to conclude that the second particle must have a complete identity outside of measurement?

The EPR paper argued that an element of matter must have a complete description which is not dependent upon any measurement. If one insisted upon interpreting the wave function of quantum mechanics (the probability of finding a particle at a given point) in terms of a single particle, this then creates a paradox in that the theory is both complete and yet incomplete.

The authors of the EPR paper, through their concept of objectivity, pointed out that quantum theory must be accepted as being complete or it must then violate the concept of the principle of local causality. Since they were unwilling to give up the concept of causality, it must be deduced that quantum theory was incomplete. The authors of the EPR paper asserted that the true judge of a theory is the degree to which the conclusions of theory correspond to human experience. They further concluded that this experience allows one to make inferences about reality. In science, that experience takes the form of experiments and measurements. Consequently, for a theory to be complete, it must require that, "Every element of the physical reality must have a counterpart in the physical theory" (Einstein, Podolsky, and rosen, 1935, p. 777). Einstein further argued that since quantum mechanics was incapable of giving values to both position and momentum at the same time (uncertainty principle), the picture of reality that is represented must be incomplete. Einstein believed that things you cannot understand or know in actuality must not exist. The EPR paradox, as it became known, was the source of much controversy in the scientific community.

With the Copenhagen Interpretation, Einstein saw an end of determinism and an abandonment of the ideal of a complete understanding of knowledge. Ultimately, around 1935, Einstein began to realize that no longer were he and Bohr debating questions concerning physics, but rather

epistemology. Einstein had argued from a position of abstract realism (the belief in a real world, independent of whether or not it is perceived), while Bohr argued logical positivism (the belief that knowledge is based upon natural phenomena as verified through empirical science). Consequently, Einstein, though he hoped for a reconciliation, could not perceive of Bohr and himself reaching one as long as they worked from differing philosophical bases.

Bohr's Defense of the Copenhagen Interpretation

After the publication of the EPR paper, Bohr set out to give a formal answer. He replied that the EPR results were fallacious because they had taken the Copenhagen Interpretation out of context. Bohr asserted that the EPR findings dealt with the history of an element, while Bohr's interpretation was aimed at the initial starting point of quantum action. Bohr (1958) later recounted his reply to Einstein. He pointed out that through the principle of complementarity, the inconsistencies shown in the EPR paper would be removed. Bohr further stated that, "The finite interaction between object and measuring agencies conditioned by the very existence of quantum action entails . . . the necessity of a final renunciation of the classical idea of causality" (pp. 59-60). Bohr still could not abandon the belief that the measurement of a particle did affect another particle in some undetermined way and continually believed that an understanding of quantum mechanics would include accounting for the act of measurement.

Bohr's rationale for this concept centered around his philosophy of science. He assumed that the purpose of science was to reduce nature to order. However, the problem arises in coordinating experiences with the

external world. Science can only understand or order nature to the degree that nature corresponds to human experiences.

The philosophy of James (cited in Stapp, 1972) help to understand the rationale used by Bohr in developing the interpretation of quantum mechanics. According to James, all human ideas originate out of the realm of experience, yet it is commonly accepted that reality consists of parts that exist outside this realm of experience. The only way to connect what is real to ideas is to consider reality as an idea. Ideas can only be compared to other ideas. It therefore becomes impossible for a mind to comprehend a correspondence between an idea and something that lies outside the realm of experience. The only evidence available that human ideas are capable of exact correspondence with the ultimate nature of external realities is the success of ideas in establishing order in physical experience. However, any success of an idea in this sphere does not guarantee an exact correspondence between the idea and external reality.

If ideas bring some sense of order to experiences, even if they do not absolutely agree, they at least agree with the experiences for which they establish order. This leads to the conclusion that ideas can only be judged according to their success and utility in the world of ideas and experience, rather than on their ability to agree with or correspond with non-ideas. This substantiates Bohr's statements as to the purpose and goal of science. It is not the purpose of science to construct a mathematical picture of the world, but rather to bring it to order.

In 1939, Einstein spoke at a colloquium at Princeton where he was asked to address the disagreement between himself and Bohr. Throughout the discussion, Einstein maintained that the laws of physics were simple, meaning whole and complete. He responded to a question from the

audience, "But if they are not simple, what then? Then I would not be interested in them" (cited in Blaedel, 1988, p. 177). Einstein ended the discussion by creating an analogy. "When a person such as a mouse observes the universe, does that change the state of the universe?" (cited in Blaedel, 1988, p. 178).

Bohr did not argue the simplicity of physics but rather that simplicity does not exist prior to the clarification of complexities. Only after one understands complexities does simplicity then emerge. Bohr (cited in Blaedel, 1988) explained that:

> . . . harmony allows itself only to be sensed, never grasped, and if we attempt to grasp it, it slips through our fingers by its essential nature. Nothing is fixed: every thought, yes, every word even, lends itself merely to emphasize connections which in themselves can never be fully described, but can always be amplified (p. 178).

These feelings outline not only the principles of the Copenhagen Interpretation, but also allude to the fundamental problem that Einstein had in accepting this interpretation. While Bohr accepted the randomness of nature as being a unique characteristic, it opened up for Einstein more questions concerning the ultimate nature of the universe and left him searching for those answers.

Conclusion

Bohr and Einstein were never able to resolve this debate. In fact, even though the scientific world seemed to be siding with Bohr, he did not perceive it as a victory over Einstein, but rather found it incomprehensible that Einstein persisted in his doubts. Einstein summarized his feelings concerning the concepts of reality being affected by the observer, events that happened randomly and without any seeming cause, by saying, "God does not play dice with the world. God may be subtle, but

he is not malicious" (Einstein, cited in Regis, 1987, p. 24). Heisenburg (1985) recalled Bohr's response to Einstein upon making this statement. Bohr (cited in Heisenburg, 1985, p. 171) countered by stating, "Nor is it our business to prescribe to God how he should run the world."

One of Einstein's most admired personal heroes was the natural philosopher, Spinoza. In Spinoza's (cited in Blaedel, 1988, p. 177) Ethics, he stated, "Nothing in the universe is contingent, but all things are conditioned to exist and operate in a particular manner by the necessity of divine nature." This philosophy seems to have laid the foundation for, or at least confirmed, Einstein's deep belief in determinism.

In 1965, Bell (cited in Pagels, 1987) dealt a severe blow to Einstein's position as espoused in the EPR paper. Bell proposed an experiment that showed the incompleteness of quantum theory presented in the EPR paper was not possible. According to Bell's experiment, either the world was nonobjective or the world was nonlocal, with instantaneous action-at-a-distance. It demonstrated that the predictions (statistical) associated with quantum theory are not compatible with an underlying reality whose independent components are linked only by a causality relationship. They must be linked in ways that go beyond a causality relationship.

The reality that was described by the Copenhagen Interpretation shook the very foundation of the scientific community. The concepts of causality, determinism, objective reality, and an ultimate truth that was to be sought by scientists, seemed now to be questionable. These concepts were being replaced by new concepts, such as probability, the need to understand relationships in order to understand potential qualities, and relative truth which is dependent upon the wholeness consisting of the observed and the observer. Scientists were also beginning to

understand the limits of language and, as a result, could only utilize the present language as symbolic descriptors of phenomena. These concepts appeared to be able to answer or describe the events that transpire in nature, yet they required scientists to utilize new methods of discovery which replaced visualization and logic with senses and statistics.

In 1982, Feynman made the statement in regards to the EPR paradox, "I cannot define the real problem, therefore I suspect there's no real problem, but I'm not sure there's no real problem" (cited in Regis, 1987, p. 33). In other words, a reality that exists outside of one's observation may still be possible.

Regardless of the correctness or incorrectness of Einstein and Bohr's arguments, they did perceive a new reality. This reality gave new value to the observer and eliminated a confining determinism as had been found in classical science. Jeans (1946, p. 216) alluded to this new reality by stating that, "Classical physics seemed to bolt and bar the door leading to any sort of freedom of the will . . . the new physics shows us a universe which . . . might conceivably form a suitable dwelling place for free men."

CHAPTER IV

THE CONCEPT OF AN EMERGING REALITY

Introduction

In 1928, Urban stated that humankind is made such that they cannot help trying to understand the universe and environment in which they live. Science begins this search by attempting to understand how a particular entity fits into its specific space and time. Science, however, transcends into philosophy when scientists begin inquiring into the meaning of the universe that they are studying. "Unless 'how did it happen' passes over into 'why did it happen,' we get nowhere, we stultify all our previous inquiry" (Urban, 1928, p. 637). The only conceivable understanding of this process is the ability to discover what is acknowledged by a society as being significant and meaningful.

Urban's (1982) concepts describe the continuous search by human beings for a meaningful reality in which they individually and collectively interact. It appears that the body of knowledge that is being sought does, to some degree, define who people are individually. When people speak of their search for identity, they are in actuality realizing that self-identity is not an absolute, but rather is qualified, relative, partial, and very complex. This realization destroys the belief in an absolute reality in which a person actively participates. If this is true, it must be deduced that to understand reality one must consider the

environment, the person, and the interaction between the two, including the language that is used to describe each.

Characteristics of Reality

The interaction between the person and the environment can best be understood or explained by reviewing the various characteristics of reality. These specific characteristics can be summarized as the ability of a person to process experiences into perceptions through the mind and thus arrive at consciousness. When one comprehends the implications of each of these characteristics, one begins to view reality as an evolving entity comprised of a complex maze of interrelated abstractions.

Whitehead (1929) began the study of reality by analyzing the ability of a person (entity) to process information. He explained that within the general context of an "entity" or "thing,"

> . . . it possesses the ability for process . . .; so 'decision' is the additional meaning imported by the word 'actual' into the phrase 'actual entity.' [Therefore], 'actuality' is the decision amid 'potentiality' (p. 43).

Given this premise, it must be assumed that the ability to make decisions supposes that there are alternatives from which to select and choose.

Hence, if an entity is not considered an absolute, then as substantiated by Whitehead (1929), existences are constantly undergoing a changing process. Existences are therefore comprised of successive momentary states and, if to each state a specific relation is assigned, then change (which is an integral part of an entity) becomes the progression of actual entities wherein each individual entity emerges rather than changes. The closest comprehendible example that we have is a single human experience that is encountered within a fraction of a second. This brief encounter is itself not experienced in its entirety, for human beings are

limited in their introspective power. They experience, feel, sense, intuit, but have only limited understanding of what, or how, they experience, feel, or intuit. As will be shown, these individual experiences have tremendous impact upon the way future encounters will be interpreted.

Entities encountered outside of momentary experiences must be identified as analogous to past experiences of the observer. Therefore, the moment an experience is encountered, it is then subjected to interpretation by the person. Consequently, reality constructs originate from the interpretation and reinterpretation of experiences. Thus, experiencing is viewed as continuous change, and when viewed as a continuum, no single part can be identified, for a point or instant is only a conceptual ideal that is part of the total continuum. When thinking about the creation of reality, one must keep in mind that experiences are only a part of reality; reality is not an ingredient of experience. Hence, it is this interrelatedness with the other distinct parts of reality that must be given consideration.

"Experience" leads one to ponder the concept of perception. Whitehead is probably the first philosopher to define perceptions as memory in regards to past experiences rather than of present experiences. By the time one sees or hears an event, it has already transpired. Consequently, any perception that one derives from an encounter does not come simultaneously with the encounter, but in retrospect. Since an event is in the process of becoming, until it has affected the person, there is nothing to experience. Thus, all perceptions of reality are in terms of past experiences. Capra (1984, p. 38) further stated that, "What we see, or hear, are never the investigated phenomena themselves, but always their consequences." This implies that one's perceptions of

past experiences hold great consequences for the interpretation of reality. For it is within the framework of past experiences that one interprets present experiences.

It is through this ability to perceive experiences that human beings are able to make evaluation and judgments regarding present experiences and future encounters. It is, therefore, the collection of these experiences that contribute to the realization of a human or an entity. Whitehead (1929, p. 163) explained that, "The defining characteristic of a living person is some definite type hybrid prehension transmitted from one occasion to another." This view of human existence rests upon the premise that there is a causal relationship between experiences of the past or present and experiences that will be encountered in the future. Whitehead (1938, p. 206) further emphasized that ". . . these unities of existence, these occasions of experience, are the real things which in their collective unity compose the evolving universe."

Bateson (cited in Capra, 1988) added still another element to the concept of reality, that being the concept of the mind. He defined the mind, "As a systems phenomenon characteristic of 'living things'" (p. 83). The phenomena associated with the mind--the ability to process information and the ability to think, learn, and possess memory--are not only manifested in individual organisms but also in social systems. According to this concept, mind is immanent not only in the body but also in the communication systems outside the body. This ability to process information and react based on recalled experiences ultimately establishes a sense of order to one's existence.

Prigogine (1976, p. 84) helped to clarify this notion of order by explaining that, "The patterns of organization which are characteristic of living systems can be understood through the concept of self

organization." Prigogine further pointed out that a living organism fulfills the definition of a self-organizing system in that its order is established not by the environment, but rather by itself; consequently, it possesses an element of autonomy. This autonomy does not mean that an entity is isolated from its environment, but rather is in a state of continual interaction with its environment, just not organized by the environment. Organization is thus determined by the function of the organism. Because an organism has the capability to organize its structure in accordance with its function, there appears to be an apparent relationship between the structure and function of the organism. Even though an organism must exist within a particular environment and interact with that environment, the concept of self-organization describes a different relationship between the environment and the organism than had previously been thought. Whitehead (1938) suggested that this structure of an organism is one element that separates human beings from animals. While animals enjoy structure, human beings understand structure. Thus, "The essence of . . . human control of purposes depends on the understanding of structure in its variety of applications" (Whitehead, 1938, pp. 104-105).

The concept of mind then leads to the concept of consciousness. According to Pankow (1976, p. 28), "The transition from prehension (grasping) to comprehension is symbolic of the emergence of consciousness." As one interacts with new experiences, one begins to develop conceptions, and it is this ability to conceive which lays the foundation for perceiving and thus transferring understanding to new situations. This concept of consciousness extends to and includes perceptions of physical things. Perceptions towards entities are structured by one's

specific time and space region, symbolic patterns, values, and one's communicative links.

Whitehead (1935) described "objects" as being antecedent entities in the process of experiencing. "Thus primarily the term 'object' expresses the relation of the entity to one or more occasions of experiencing" (p. 178). Another word for object might be the "data" for that specific encounter. Consciousness thus becomes an emphasis upon a selection of these objects, while perception is the analysis of consciousness in respect to those objects selected to be emphasized. Consciousness, therefore, emerges as the height of emphasis.

Whitehead (1938) ascertained that there must be a unity between individuals and their environment. Hence, the only way that an individual can comprehend one's environment is to translate or interpret that environment in terms of one's own world or consciousness. Unless there is a fusion between the physical world and the essential elements whose interconnections constitute the universe, one can never hope to comprehend nature or life. What living entities understand about themselves in relation to the universe is through experience. This concept of experience includes total body experience--including both reason and emotion. An entity is never able to isolate its experiences, but rather sees the experiences in relationship to the universe. Consequently, all experiences include the individual self and one's consequential value or relationship to the universe.

Four major elements have thus far been discussed in determining how reality is created. They include: experience, perception, mind, and consciousness. Seemingly, all four of these ingredients are essential to individuals in understanding their interaction with their environment, and thus become the key components in reality. Yet, no matter how

important each of these elements may be to that reality, they individually are not reality.

Communicating Reality

Once a person becomes aware of self-reality, one experiences the need to communicate that reality, either to oneself or to others. Language has emerged as the primary means of communication among human beings. Whitehead (1938, p. 44) asserted that, "Language is the triumph of human ingenuity surpassing even the intricacies of modern technology." Any discussion of reality must include a discussion of language, for it is through the use of language that people describe their environment. Whitehead perceived the role of language, whether written or spoken, as being an instrument by which humans are able to adjust to their environment. Consequently, language serves two functions. First, it allows one to communicate with another; second, it allows one to communicate with oneself.

As a tool for adjustment, language assumes many purposes in obtaining or in aiding that adjustment. The most basic use of language is merely a series of squeaks whose purpose is to express emotion or to communicate. Words can also be utilized to record and consequently retain experiences in memory. These words then make it possible to, or at least provide assistance in, the recall of past experiences. It is through the use of language that humans are then able to give a semblance of organization to experiences as they are remembered in retrospect. As a means of communication, language allows human beings to comprehend the past and consequently to make predictions concerning the future. Whitehead (1938) espoused that language is the expression from an individual's past into the present; therefore, language carries with it meaning

derived from realities of the past. Consequently, past experiences hold tremendous implications for present experiences due to the meanings and concepts associated with the language that is used to judge present encounters.

However, there are some basic problems in describing reality through the use of common language. One such problem associated with language is its deficiency in meaning. There are evident variations in the meanings associated with a language, even though these variations are not easily verbalized. Thus, it becomes impossible to incorporate into a train of thought what one apprehends in mere flashes. Consequently, one is left only with the deceptive identity of an individual word. Because of this specific limitation, language must be perceived or utilized as a ". . . tool-making function of one's intelligence" (Urban, 1938, p. 621). However, it cannot be allowed to become an "absolute" in that it possesses the ability to curtail one's search for true expression.

Putnam (1975) addressed this vagueness of language through the concept of "notion of reference." This concept is defined as, "What 'fits' a description is what the description refers to; that is, what the description is true of" (Putnam, 1975, p. 283). The relationship between the world and word is the ultimate definition of "reference." A prime example of this concept is Bohr's description of an electron. It is impossible to find a particle in existence which completely fulfills Bohr's description of a particle. What is found, however, are particles which approximately fit the description. They contain the appropriate charge, mass, and, "Most important, they are responsible for key <u>effects</u> for which Bohr thought electrons were responsible" (Putnam, 1975, p. 275). Consequently, we are left with a word whose definition does not exactly match the reality of an entity.

Not only is vagueness of definition a problem associated with language, but also the ability to understand the definition produced emerges as another problem. Modern knowledge is utilizing mathematics more and more in the description of current reality; however, it also must be remembered that mathematics is a unique correlation between language and reality. To comprehend the reality that is described mathematically requires an individual to have an understanding of the language utilized to express that reality. For example, consider how the world must appear to someone who has never heard of or comprehended any scientific descriptions of the cosmos. The earth must appear flat and the sun and moon appear as shining discs that appear daily. This person will not be able to comprehend the concepts of a solar system, gravity, or planetary motion. Through common sense, they will deduce that bodies fall to the ground, not because of gravitational forces, but rather because there is nothing to hold them up. This same common sense provides this person visualized answers explaining the environment. These answers are communicated between members of the culture and therefore, linguistically meet the needs of the society. However, when these words can no longer adequately meet the needs of this society, then they will work out in language new answers that will fulfill needs. As illustrated, one's ability to comprehend and describe reality is dependent upon the conceptions of language and, unless one has a thorough understanding of definitions and concepts associated with a specific language, one's perception of reality can be radically altered accordingly. Consequently, one's reality or understanding of reality may vary from one to another, dependent upon understanding of linguistics used for description.

Regardless of the problems associated with language, it is still the primary medium for communication and thought among human beings.

Whitehead (1938, p. 57) stated that, "The souls of men are the gift from language to mankind. The mentality of mankind and the language of mankind created each other." Therefore, it is through language that humans have the ability to express their thoughts and thus verbalize their reality.

Knowledge in Reality

It becomes quite obvious that individual reality is dependent upon the development of consciousness of experiences and it is as one interacts with the environment that one builds a repertoire of experiences which will determine reactions to future experiences and encounters. Therefore, it can be concluded that what one sees in reality depends not only upon what is looked at, but also what one's ". . . previous visual-conceptual experiences has taught [them] to see" (Kuhn, 1970b, p. 113).

Language thus becomes the format through which human beings attempt to describe and organize these experiences, for emerging experiences must be interpreted before they can become knowledge.

> Every language is a vast pattern-system, different from others, in which are culturally ordained the forms and categories by which the personality not only communicates, but also analyzes nature, notices, or neglects type of relationships and phenomena, channels his reasoning, and builds the house of his consciousness (Carroll, 1956, p. 252).

Therefore, it can be logically concluded that consciousness is the foundation of knowledge. Thus, if knowledge does exist, it can only be uncovered as part of the total experience of an entity. To Whitehead (1929), knowledge is to be found in conscious experience or verified through intuitive observation. Whitehead (1935, p. 177) continued by defining knowledge as the ". . . conscious discrimination of objects

experienced." Therefore, knowledge and experience are forever linked together within the realm of reality.

To illustrate these three approaches to reality, Jantsch (1975) utilized the concept of a stream and an observer to create a metaphor that demonstrates the relationship between the observer and the object of observation. The first picture drawn shows the observer sitting on the edge of the stream, noticing the various characteristics of the water. In this particular setting, the observer is objective in witnessing a reality that exists independent of observation and measurement. It is a reality that can be measured, predicted, and studied, with the observer having no impact whatsoever upon its existence; it is a value-free reality. The observer is merely, ". . . the objective knower of the stream, the known reality" (Haggerson, 1988, p. 84).

The second scene depicts the observer in a boat in the stream. The observer attempts to guide the boat by monitoring the features on both sides of the boat. By keeping close watch on both banks, the observer attempts to keep the boat centered in the stream. The result is that the observer now becomes emotionally involved because of the feelings experienced resulting from the interaction with the stream. This emotion thus moves the observation from an objective state to a more subjective state, for the observer is not only concerned with ideas, but also with feelings. However, the stream is still objective in that it can be measured, but in this case, the measurement will reflect the presence of the observer. Jantsch (1975) perceived this reality as being mythological in that the order originates from qualities that are subjective and their interactions. For example, one's daily life is comprised of interactions with objects which can appear either friendly or threatening, and as a result, order is established as a consequence of one's perceptions of

outside forces. This reality is concerned primarily with the ". . . conditions of [one's] captivity in a world which is happening to [them]" (p. 86).

The third picture of this metaphor shows the observer becoming the stream. They actively participate in all of the movement and become part of the unique characteristic of the stream. However, though they are the stream, they are only part of it. This approach to understanding incorporates a true hierarchical relationship. As one descends in the hierarchy, a better understanding is gained of the microscopic processes involved with the system. Conversely, as one ascends in the structure, more meaning is given to the lower levels. Through this view of reality, opposite forces which become threatening in the other scenarios are, in the third scenario, perceived as ". . . the emerging force of a forward thrust" (Jantsch, 1975, p. 99). Consequently, the oscillation between the forces becomes part of the evolutionary process. Hence, reality is not stagnant, but is ever changing. Where the mythological reality still possesses an element of a measurable reality through adaptation (adaptation between observer and stream), the third concept or picture is never measurable, for it is in a constant state of change. Therefore, it is perceived as evolving, with the observer being an integral part of the evolutionary process.

This illustration or metaphor of an individual and a stream helps one to visualize the options that are available to society in understanding the role or relationship that exists between the observers and their environment. The relationship, in each case, portrays a different reality. Reality moves from being a separate entity to be observed and actualized, to one that cannot be understood or defined separate from the observer. The observed runs the gamut from objective to subjective, from

unemotional to emotional, and from a controlling/ordering force to one that has only one element that contributes to control/order.

Conclusion

The paradigms that are held by a society have tremendous effect upon the individual members of that society. Given the definition of the word "paradigm," as explained in Chapter I (Kuhn, 1970b; Capra, 1988), it is indicated that the theories, images, and beliefs/values held by a culture have tremendous influence upon the destiny of the individual members. Therefore, one must, when attempting to understand reality, consider how a society or culture views reality, including the language used to describe that reality. Social scientists have described Americans as having

> . . . a deep desire for autonomy and self-reliance. We are a nation founded in independence. Separateness is a cultural norm for us. Our heroes are lonesome cowboys and hard-boiled detectives who work by themselves. Our economic system is based on individual enterprise, entrepreneurship, and competition (Tye, 1990, p. 1).

When analyzing this description of American society in reference to paradigms, one begins to comprehend the forces that have existed to shape this independent and self-sufficient society. The industrial era has created a reality and thus an understanding of human life that appears to be diminishing in validity. Markley (1976) identified three premises of society which seemingly have been taken for granted, yet are now appearing to be obsolete. They include:

1. Human progress is synonymous with economic growth and an increasing consumption--a notion now challenged by shortages of various key resources and increased pollution.

2. Mankind is conceptually separated from nature and it is the human desire to conquer and exploit nature--an attitude at distinct variance with modern understandings of ecology.

> 3. Economic efficiency, specialization, and scientific reductionism are the most trustworthy approaches to fulfillment of human goals--concepts that have raised our standards of living, but are dehumanizing our way of life (p. 223).

Kuhn (1970b) pointed out that a characteristic of anomalies is their persistent refusal to fit into the existing paradigm. Therefore, these irregularities will lead to the discovery of new theories that attempt to answer the anomalies. The mere fact that these premises identified by Markley are no longer describing human existence with any degree of accuracy results in anomalies within the dominant paradigm of society.

Just as anomalies are an inevitable ingredient of a paradigm, so too is the ability to interpret a paradigm, for it is through interpretation that a paradigm is articulated within a given society (Kuhn 1970b). As shown earlier in this chapter, we interpret or understand new experiences in light of past experiences. Yet, when we move into a new paradigm, we cannot logically transfer complete understanding of past experiences of the old paradigm over into the new, for words change meaning from one paradigm to another (Kuhn, 1970a). Kuhn described this incompatibility of paradigms as being incommensurable. He stressed that once a translation is made concerning the meaning of the word, inevitably there will be compromises between the original meaning and what is possibly acceptable. Bohr's difficulty in comprehending the wave-particle duality (see Chapter III) illustrates this concept of incommensurable theories or paradigms. He found himself torn between the terminology and concepts of classical science and the characteristics of quantum mechanics. When Bohr applied the terminology and concepts of classical mechanics to quantum mechanics, he found that the terminology and concepts were no longer valid.

This illustrates a major problem with language, which was addressed by Whitehead (1929), that being the need for a new or redesigned language

that more accurately describes the emerging reality associated with a new paradigm. If language is not molded on reality, then any attempt to describe reality with ordinary language will, to some degree, distort that reality. This assumption relies on the premise that society can somehow comprehend the character of nature apart from the language and then identify the areas in which language and reality do not correspond. To correct this problem, society must seek new terminology which more accurately describes the relationship between human beings and their environment.

Markley (1976) identified some characteristics of human beings which are creating a new image of the human being in this evolving paradigm. Though not a complete list, it includes visualizing humans as:

1. entailing an ecological ethic, emphasizing the total community of life and the oneness of the human race;
2. embracing a self-realization ethic, placing the highest value on development of the individual;
3. conveying a holistic sense-of-perspective of life;
4. balancing and coordinating satisfactions along many dimensions rather than over-emphasize[ing] those associated with status and consumption;
5. experimental and open-ended, rather than ideological dogmatic (p. 225).

This list, though only partial in scope, describes a humanity that is not separate from its environment, but rather is intertwined and interrelated with the components of the environment. Thus, to define either the environment or the individual as separate, independent entities becomes an impossibility. To fully understand or comprehend the environment requires comprehension of the other individual, yet, to identify characteristics of either requires that the moment in a specific space at a given time be "frozen." This attempt to gather knowledge thus

interrupts the continual process of changing and emerging identities. As Heisenburg and Bohr found it impossible to fully understand reality in a changing and evolving environment at the subatomic level, so too is it difficult to comprehend fully reality when dealing with the human race.

One must also understand that the language currently being utilized to express, describe, and communicate this new, emerging reality reflects the values and definitions of an "old paradigm"; thus, it no longer can be used to describe accurately what is transpiring in the new paradigm. In the scientific community it has become quite obvious that the language being used to describe natural phenomena is totally inadequate, therefore diminishing to some degree the accuracy of description. Yet, for human comprehension, some familiar terminology is required. As stated by Rogers (cited in Friedman and Donley, 1985, p. 64), "Where the new cloth meets the old cloth, they must agree."

If this is true in the world of science, so too is it true in the world that includes human beings. However, progress must be made in bringing about not only a better understanding of the identity of humans, but also their relationship with their environment, including new terminology that accurately describes the process of an emerging and continually changing human reality.

CHAPTER V

THE ONTOLOGICAL MEANING OF THE COPENHAGEN INTERPRETATION FOR CURRICULUM THEORIZING

Summary of Study

As shown in Chapter II, the classical scientific paradigm has provided the knowledge base from which twentieth century curriculum theorists have developed curriculum theory. The knowledge base that has been borrowed from the scientific community contained several important premises that must be identified before one can hope to comprehend the resulting reality. These premises include an objective reality, determinism, the principle of causality, and reductionism.

Given these premises, the universe and the environment were assumed to be separate entities; therefore, natural phenomenon could be viewed in their entirety by the observer. The role of the observer was primarily to understand the principles of nature. In an effort to understand these principles, classical scientists realized that through reductionism and causality, a whole entity could be understood by identifying its rudimentary parts and their corresponding relationships. Therefore, the principles of causality and determinism allowed scientists to make predictions concerning future behavior, thus creating a very orderly and precise universe.

Since the theories of classical science could provide acceptable answers to society concerning nature and the universe, society began to accept the premises from which scientists derived these theories. Curriculum theorists followed suit, and thus began viewing curriculum theory within the same constructs of science. Consequently, curriculum theorists perceived the child and curriculum as two separate entities, and correspondingly, education became no more than the sum of its parts. As witnessed in science, curriculum theorists began identifying those parts and their causal relationships; hence, educators could structure the entire educational experience in an orderly and predictable fashion.

In as much as classical science has provided the foundation of twentieth century curriculum theory, does it not hold true that a new paradigm in science holds the potential for an alternative for curriculum theorizing? The Copenhagen Interpretation has subsequently challenged the basic principles of classical science. This new scientific paradigm is founded upon new premises concerning nature; therefore, new scientific methods are required if science is to comprehend what it is now able to observe at the atomic and subatomic levels. These new methods and resulting theories have forced scientists to rewrite the definition of reality. No longer is nature perceived as a separate entity, but rather nature and the observer are intertwined and interrelated. To understand nature requires understanding its relationship to the observer. The question then begins to emerge as to whether or not any entity has an independent identity outside of its relationship to the various forces within a given system.

The principle of uncertainty and the principle of complimentarity seem to offer insight into these questions that scientists began asking in terms of quantum mechanics. In search of answers to these questions,

scientists began to change the focus of their questions, accepting that there were no absolutes and acknowledging the value of each entity that comprised a system. Thus, a new reality emerged.

The thesis of this paper was to determine if the Copenhagen Interpretation could provide an alternative framework for curriculum theory. Could the premises and methods used to describe the new reality in science have any value for curriculum theorists? If history holds true, this author feels that the fundamental ideas of the Copenhagen Interpretation do provide a new way of defining the educational process, the roles and relationships between the students and teachers, and the total design of curriculum theory.

Reality and Curriculum Theory

The scientific methods used by Heisenburg and Bohr reflected the premises that they embraced concerning nature. They discovered that reductionism was no longer relevant at the quantum level (see Chapter III). Because particles exhibited random characteristics, scientists could not hope to understand a system by comprehending its individual parts.

As was shown in Chapter II, educators have also attempted to break down, categorize, and label children according to their exhibited abilities. Not only are students divided into groups according to this ability, but schools then attach "descriptive" labels to them, such as "gifted," "regular," "learning disabled," and "emotionally handicapped," to name only a few. By dividing students into specific groups, educators are attempting to divide the student body into the elemental parts that comprise the whole for the sake of order. Identifying labels are then necessary to distinguish between the many and varied groups.

The problem arises in that the descriptive labels carry with them predetermined concepts as to how a student will perform in class. Not only does it describe how a student has performed or will perform, it also prescribes the type of teaching strategy and curriculum used with the student. For example, a child who has been identified as learning disabled will be taught concepts that are not as complex as those taught to children who are identified as gifted. Whereas gifted students are expected to be able to comprehend complex concepts, the same expectations are not held for the learning disabled student because of their identified disability. As a result, many times these students are never exposed to the more complex concepts, or they are presented in a "watered down" fashion. In retrospect, "labeling" was the result of an effort to provide a quality education for the many different children who enter the schools. However, in an effort to help children achieve their individual potential, it required that schools identify or label according to their strengths and/or weaknesses.

This illustrates the language deficiency in education that Whitehead (1929) identified, that being the inadequacy of language to describe actual entities (see Chapter IV). The question arises, "Just what is a 'learning disabled' student, or what is a 'gifted' student?" Many educators possibly would respond by stating that learning disabled students are ones possessing a certain deficiency in the manner in which they learn; whereas, gifted students demonstrate certain abilities which allow them to excel in certain areas. In many cases, if questioned further regarding how it was determined that a child is either "learning disabled" or "gifted," a major indicator would be a child's performance on a specific test. Therefore, through testing or a specific measurement, children are categorized according to their characteristic abilities and

then are tagged with a descriptive label which denotes their specific place in school.

This author feels that education is experiencing the same problems that Bohr experienced in describing the electron. When utilizing common language to describe subatomic activities, Bohr could only describe characteristic features rather than actual entities. He was able to identify the distinguishing characteristics of particles such as mass, charge, and appropriate effect, but nothing existed that corresponded exactly to Bohr's description. The same is true in education. Students are identified and labeled according to characteristics that are demonstrated at a specific time, yet does that descriptive label accurately describe the whole child?

The total design of schools also reflect this inadequacy of language. Schools are divided according to specific grades; for example, first grade, second grade, third grade, etc. The question is, however, what is "third grade?" There is no concrete entity that is third grade; however, one can describe the characteristics of third grade. It normally represents a child of a specific age range who is taught certain math skills, along with specific language skills, science skills, and social studies skills. What skills are taught are usually built upon the skills that were taught in the "second" grade. But to say "this is third grade," or "there is a third grader," is only to describe certain predetermined characteristics. Yet, the educational system is so designed that children fail third grade, something that in actuality does not exist except for the convenience and organization of the educational system, which (as stated in Chapter III) was the purpose of scientific descriptors.

Language has always been society's way of communicating, both individually and collectively, for through the commonality of words and corresponding definitions people have been able to describe encounters, express thoughts, and communicate ideals. The problem, however, is that the language used is, in many cases, only able to describe characteristics rather than discrete facts. Scientists such as Heisenburg and Bohr found in the scientific world that common language could only describe the results of experiments; consequently, the language utilized could only be used as a ". . . complementary mode of description" (Holton, 1973, p. 118). However, in society, "Language which is intended to explain or describe reality [often times] becomes reality" (Dobson and Dobson, n.d., p. 4).

When one considers experiences and the language used to describe those experiences in the context of curriculum, one begins to understand the impact of science and society in creating the reality that has for years been experienced by students. One then must ponder the effect upon the individual student, of not only the experiences that are encountered in school, but also of the language used to describe those experiences.

When reflecting upon Whitehead's description of the creation of knowledge and thus reality, one realizes the importance of experiences. As stated in Chapter IV, once a person encounters an experience, he or she instantly interprets that experience in light of past experiences. If this is true, the experiences that a child encounters in school are helping to build or create knowledge held by that child. Whether it be through the process of labeling, ability tracking, or the piecemeal method of curriculum, all are helping to construct a child's perception, not only of himself or herself, but also of the environment in which they interact. Thus, each experience provides the framework from which future

experiences will be reacted to and interpreted. This is what Whitehead identified as perception and consciousness. Therefore, when students experience failure or the effects of labeling, it contributes to their consciousness, which transcends into the knowledge that they have not been able to succeed or are identified by some peculiar label. Henceforth, their reactions to future experiences will be reflective of those past experiences or encounters in school. If one acknowledges the role of experiences in creating knowledge, one must consider the experiences had by a child in the "reality" of school.

Jantsch's (1975) metaphor of the stream and independent observer gives insight into three general, yet unique, approaches to reality (see Chapter IV). Each scenario requires that the observer assume a different role in relation to the stream, consequently altering the value of the observer in each. This author feels that since schools are still functioning within the parameters of the classical paradigm, the current reality in schools (and curriculum theory) can be described by analogy with the first and second pictures that Jantsch's metaphor employed.

In the first scene, the observer is on the bank being an objective observer, and is able to view, measure, and describe the specific features of the stream. The observer has no control over the stream and neither does the observer's presence effect the stream. They are two separate entities. In considering curriculum, there has been a predetermined body of information deemed by society to be important. According to the structure of schools, the information is broken down into simplistic terms and is presented in piecemeal fashion according to grade levels. Consequently, a child in a specific grade will be taught skills regardless of ability and/or interest because it has been accepted in education that age level determines the ability to comprehend.

Therefore, children should not be taught whole concepts, but rather in building block fashion information is dispensed until a child is old enough (whatever age that may be) to comprehend the complex whole.

In an effort to organize this building process, educators have developed stated objectives which have been methodically sequenced, such that a child can be carefully maneuvered through the maze of objectives until he or she has successfully mastered the whole of knowledge. In most cases, the sequenced objectives span several grade levels. Success of achievement is determined through testing or some other method of measurement, and there seems to be no interrelatedness between the student and the information that is to be gained. The information determined to be important is a separate entity from the student, and the educational experience can be independently observed and measured. Just as an objective reality exists between the observer and the stream, so too is the student objectively viewing curriculum presented in school.

The second scene described by Jantsch (1975) sees the observer in the stream. The observer's own physical features, and weight and mass, affect the stream, but by compensating for the observer's presence one can still understand the stream separate from the observer. Schools also attempt to compensate for the presence of children in the learning process. By determining ability and attempting to teach towards the various learning styles, educators try to adjust the educational process according to the needs and strengths presented by individual children, yet the learning process and the child continue to be separate entities. Learning is still measured, and if measured, requires something to measure against which reflects predetermined objectives. Just as illustrated in the first scene, the child is an observer of the learning process.

Both scenarios are products of the classical paradigm. For curriculum, the classical paradigm includes the reduction of information into simple facts which will be presented in specific grade levels, and as students progress through grades, they will add to their previously learned facts. The information is something to be acquired by the learner and the success with which one acquires that information will be predetermined by what educators deem successful.

Admittedly, there are always new trends in curriculum that attempt to improve or revolutionize education. These have ranged from open schools to individualized instruction, to stated learner outcomes, to only name a few. Each has attempted to provide new approaches to learning which will result in higher student achievement. However, if one identifies the premises on which these new methods are founded, one finds they are just another model (which is what Tyler, 1949 provided) for teachers to imitate. For by following specific steps or procedures, teachers will, in turn, be able to help students experience success in the learning environment. Learning once again becomes objective, and thus a separate entity from the child with the teacher directing the learning experience through specified rituals. These various attempts at revolution, regardless of how they may differ in methods or style, all share a common conceptual base of education.

The conceptual base for education under the "classical paradigm" is very reflective of Newtonian science. Every component of education, whether it is curriculum, school structure, or the student body, is broken down, identified descriptively, and observed objectively. Just as Newton observed that the universe followed mechanical laws, reality in schools can also be described as mechanical. It is orderly, deterministic, and predictable, much like the workings of a clock.

The Potential of the Copenhagen Interpretation for Curriculum Theory

This author feels that the Copenhagen Interpretation does provide an alternative conceptual base for reinterpreting the schooling process. If so, consideration must be given to the premises, methods, and theories used by Heisenburg and Bohr in arriving at this interpretation of quantum mechanics.

The epistemological approach from which Heisenburg and Bohr functioned has been identified as logical positivism. This philosophy allows one to assert truth in logically opposing models. For example, it is acceptable to assume that the "particle" characteristic of an electron is true for a specific time. However, it is also true to state that the electron exhibits a "wave" characteristic at another point in time. Given this epistemological point of view, it is assumed that either definition of an electron is true and that the current description is all that can be said about the entity at that specific time. This knowledge base embraced by Heisenburg and Bohr allowed them to introduce into the field of science both subjectiveness and free will.

This author feels that this approach brings an element of freedom into curriculum theory. Educators should not be required to make decisions concerning students or even curriculum that then become "cast in stone." Decisions that are made as to what will be taught or how it will be taught should be viewed as being appropriate for a given time. Yet, educators should have the freedom to change these decisions if and when circumstances at another time warrant the change. For example, a teacher may decide to present a specific unit one year because various students demonstrate a sincere interest in the topic. The following year,

however, the next group of students may have absolutely no interest at all in that topic, yet may show interest in another area. Therefore, the teacher should be allowed to develop curriculum as the needs and interests of the students present themselves. This flexibility can even be applied to the every day lessons that are taught in individual classes. The methods used with one group of students quite possibly will not work with another group of students, given the personalities and atmospheres of individual classes. The author does not mean to imply that curriculum should have no order or consistency. Most people will agree that students need a basic understanding of such things as English, math, science, and history; however, for the curriculum to be prescribed by an outside entity such that the teacher cannot allow students to pursue their own knowledge, curriculum becomes a restrictive rather than an enlightening force.

This philosophical attitude not only provides greater flexibility for the teacher but also widens the door of opportunity for students. Students of all ages, and especially adolescents, are very volatile as a result of their biological changes. Students' abilities to perform will vary from day-to-day; their interest will vary and their goals will change. As long as students are allowed to function according to who they are without the schools determining who they are according to premeditated standards, students will have the opportunity to grow, experience, and develop their own abilities and reach their fullest potential without being confined by the technicalities of school. This epistemological foundation thus allows enormous freedom in curriculum and the individual child becomes a guiding force in the educational process.

The principle of complimentarity also offers an alternative way of viewing the child in the classroom. A child that sits at a desk assumes

the role of a student, yet that child has many other characteristics that contribute to the total identity of the child. Not only is that child a student, but when they go home they become part of a family unit in which they assume new characteristics. They may become the primary interpreter for parents who cannot speak English, or they may have to contribute significantly to the family income. In today's society, many children are part of a single-parent family and, if there are younger siblings, the child may have to assume the role of parent. As illustrated by the concept of complimentarity, to fully understand the child in the classroom requires that consideration be given to the other qualities and/or circumstances that are exhibited or experienced outside the classroom.

It is also important to realize that a change in any one of the above mentioned characteristics will probably affect the other characteristics in one way or another. Many times a divorce in the home will affect the student in the classroom. Conversely, students experiencing difficulty in the classroom can, in turn, begin to cause problems at home. Bohr concluded that his knowledge of an electron rested upon knowledge of the qualities of the electron (position and velocity). Educators must come to this same realization when working with children: the more information known about the whole child, the more the teacher will be able to understand the reality from which each individual child emerges.

If the concept of complimentarity is applicable to curriculum, consideration must be given to the concept of balance. Students must be allowed to achieve a balance within their various qualities if they are to achieve their fullest potential. This must be recognized not only by educators but also by parents. Some students are so motivated to achieve (whether internally or from an outside force) in athletics, in academics,

or socially, to the extent that their other qualities (including the ability to be a child) are, in turn, forced aside. In some fashion, children must be allowed to nurture all of their various qualities, at the sacrifice of none. This is not to say that at times a child will not focus on one area of his or her life more than another, it simply means that in the whole of who a child is, they must be encouraged and provided the opportunity to explore life to its fullest. This balance in a child's world again illustrates a fundamental premise of complimentarity. Bohr found that the more he knew about the momentum of an electron, the less he understood the position. Hence, to achieve the fullest knowledge of the electron required a balance between both momentum and position.

Not only does the principle of complimentarity offer insight into understanding the child, but the basis of Bohr's (1987) defense of the Copenhagen Interpretation offers new alternatives for curriculum theorists. Bohr was convinced that science could never hope to comprehend fully an observed system due to quantum reaction. Therefore, he was forced to accept statistical descriptions of possible characteristics. Bohr also discovered that once a measuring instrument was introduced into the system, the motion of the particles altered. As a result, reality was in a constant state of change and was continually emerging. Bohr concluded that the attempt to isolate a measurement resulted in the disruption of the continuum of motion.

If this finding offers any insight into curriculum theory, one must reevaluate the concept of education. Is education a "stagnant" experience, or is it an ongoing and emerging process? If it is an ongoing process, then to try to measure or test a student's progress or learning attempts to isolate a specific point in the learning continuum. Consequently testing only shows a small part of an ongoing process and thus

alters the total picture. Just as the measurement for velocity altered the knowledge of the position of an electron, so too does measuring or testing alter the whole view of the educational process.

In order to gain access into the atomic and subatomic world, scientists were subsequently required to sacrifice the ability to visualize reality fully. Consequently, scientists were forced to rely upon intuition in their search for understanding and the ultimate particles of nature. Once intuition enabled scientists to grasp the concept mentally, mathematics provided the verification.

This author proposes that intuition is a vital part of curriculum theory; this can be verified in light of the Copenhagen Interpretation. Intuition liberates a teacher from mandated methods, learning objectives, and even teaching models that are considered in "vogue." Through intuition, a teacher is able to become part of the emerging and continually changing learning process of education. It thereby allows the teacher to assist students individually and collectively according to the needs and desires of the students. However, for teachers to depend upon intuition and be successful, they must be sensitive to the various realities that children bring with them into the classroom.

This author feels that the Copenhagen Interpretation has the potential to force curriculum, or allow curriculum, to move into Jantsch's (1975) third scenario of reality. In the third setting, the stream and the observer become one. The observer cannot be separated from the stream; therefore, measurement becomes impossible. To understand the stream, one must understand the observer, and to understand the observer requires understanding of the stream. There are no separate entities that exist outside of their relationship to the whole; therefore, knowledge is not "out there to be acquired," but rather is ongoing and

emerging, with the individual child being an active participant in the learning process.

If the stream can be compared to the learning experience, it necessitates an understanding of the individual child (observer). Children bring with them a whole baggage of experiences outside of school that contributes to the total child. These experiences range from ethnic and economic backgrounds to religious beliefs and moral upbringing. If past experiences determine future interpretation of experiences, a teacher cannot expect to dispense information to a child and then anticipate the child's reaction to that information. A child's reaction to the learning process is reflective of all the collective experiences of that individual. Consequently, it will be impossible for a teacher to comprehend fully the reality that the child brings into the classroom. Therefore, the child and the learning experience cannot be separated, but are fused together as one entity. The role of the teacher will become that of a resource person providing assistance to children as they seek to guide their own learning.

Again, the author does not mean to give the impression that future curriculum can have no structure or method of determining growth--only that the search for knowledge will be a cooperative effort between the student and the teacher. The student will be allowed to pursue his or her own interests at a self-determined level of ability, and with the cooperation of the teacher, can explore new areas of knowledge. If evaluation is necessary, then it must be from the unique perspective of the child, for only the child can assess feelings of achievement.

In this type of cooperative learning environment, structure and order will come from within the system, rather than mandated from an outside force. Structure and order will emerge as is needed within the

classroom at a given time. If systems organize themselves according to their purpose (see Chapter IV), the classroom and curriculum will be organized according to the needs of the students rather than the bureaucratic needs of the administration, state department of education, or legislature.

Does one ever question why classes are divided into 55-minute segments, or why history is taught at a particular time and literature at another? In most cases, the decisions are made to accommodate the time that has been allotted by the community or dictated by the local board of education. Some of the factors that enter into these decisions include bus schedules, athletics, or band--to identify only a few. Whatever the reason may be, decisions are many times made with the needs or desires of the students being of last priority.

As a possible alternative to this segmented structure, consider the possibility of teaching certain subjects together. Much literature could be learned in the study of history, or mathematical principles in the study of science. By taking a wholistic approach to curriculum, students are instantly able to perceive the relevance of subjects which, in turn, can open new doors of knowledge for them to investigate.

If one looks to the Copenhagen Interpretation for possible alternatives to curriculum theory, one finds that Heisenburg and Bohr were forced to relinquish their desire for "absolutes." The reality they witnessed was statistical, probabilistic, and appeared random. However, by gaining an understanding of the randomness of nature, Heisenburg and Bohr were able to restore order to their reality.

The alternatives that this author has mentioned appear to introduce randomness into the field of curriculum. However, by understanding that

apparently chaotic and disorderly approach to curriculum, order is once again restored to the learning process.

Conclusion

The statement, "I once took the moon to be (or saw the moon as) a planet, but I was wrong" (Kuhn, 1970b, p. 115) illustrates what happens as a result of new knowledge or understanding. Once scientists expand their knowledge and begin to see the world in light of that knowledge, they describe it in terms of ". . . scales falling from their eyes or [a] lightning flash that inundates a previously obscure puzzle" (Kuhn, 1970b, p. 122). Can this same experience be translated into curriculum theory? This author feels the same is true for curriculum theorists.

If the past sheds any light upon the future, the Copenhagen Interpretation will undoubtedly affect society, including curriculum theory. Is this to say that what schools have been doing in the past century has been wrong? If so, one must say that Newton, one of the finest minds of all time, was wrong. One must realize that times change and societies change, and as in the field of science, knowledge is acquired in a piecemeal fashion. Knowledge, which at one time seems to be reality, becomes the basis for further studies whose results will make the original knowledge appear obsolete and, in time, mythical. The same is happening in the field of education. What has been the foundation of education no longer is serving its function, and therefore is leading into a new reality in school, requiring a new language and new concepts to describe that reality.

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