Theoretical Foundation in Educational Psychology for Multi-Intelligent Online Learning

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Introduction

The theoretical foundation for Multi-Intelligent Online Learning lies in the areas of cognition and learning theory in the field of Educational Psychology. The shaded box in the lower left corner of Figure 1 depicts the theoretical foundation in Educational Psychology. In order to understand the theoretical foundation underlying the research and the educational methodology used to develop the prototype Multi-Intelligent Online Learning modules, this paper discusses and reviews literature in aspects of cognitive science and learning theories.

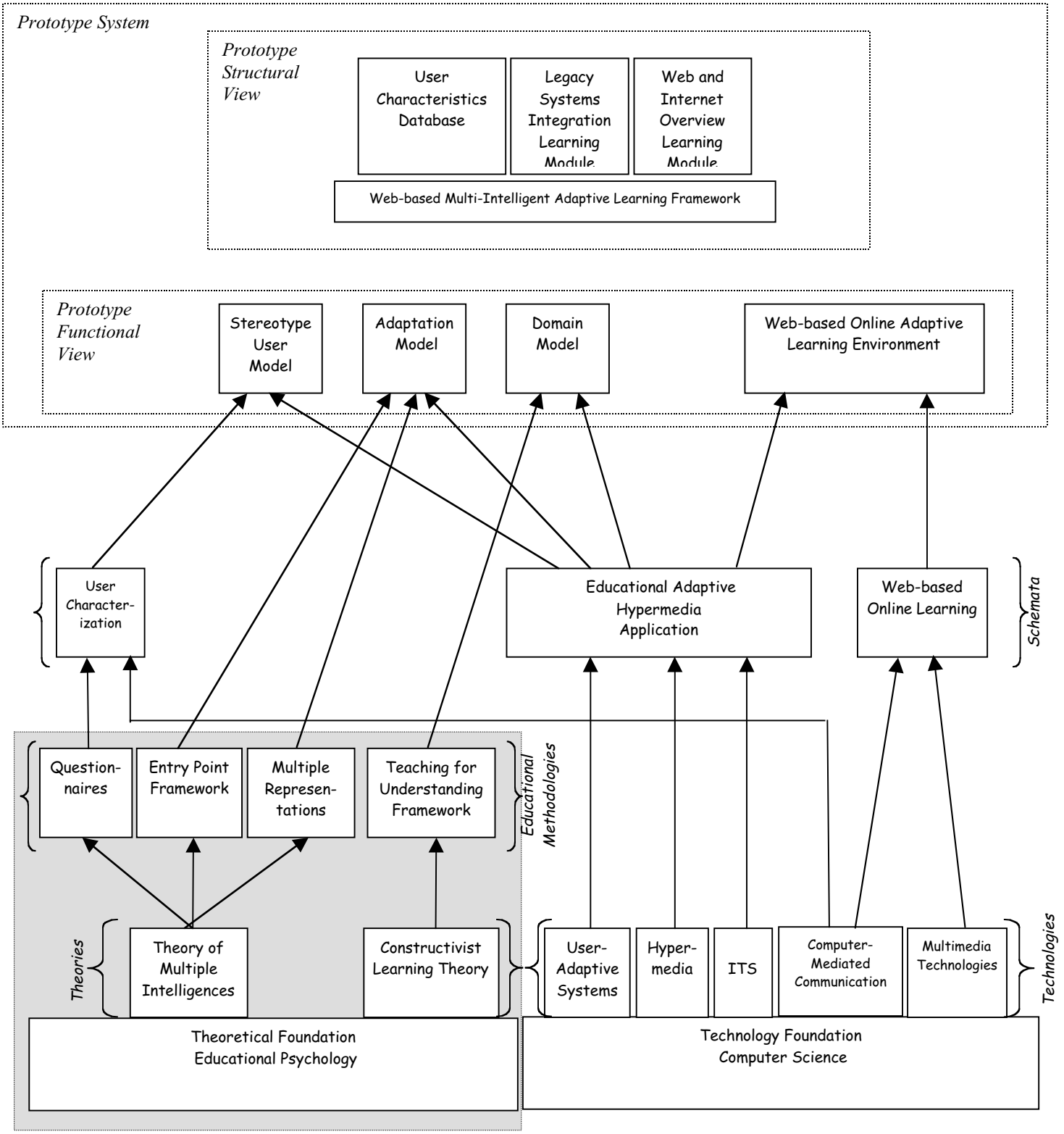
Many people undertaking the task of developing an online learning system rely on a pure technology approach. However, the approach taken in Multi-Intelligent Online Learning is one that uses cognition and learning theory from the field of educational psychology to inform the design of the online learning framework and modules. Readers with a background in technology may need an understanding of cognition and learning theory and educational methodology.

Therefore, this paper provides an overview of learning theories, a discussion of contributions from various fields to understanding the processes of learning and knowing, and an overview of specific individual approaches to learning and understanding. This overview is intended to provide readers with sufficient background knowledge in cognition and learning theory to lay the groundwork for Multi-Intelligent Online Learning.

The first section explores models of thinking from cognitive science, providing a brief history of the field, presenting three major approaches to modeling thinking: symbolicism or classicism, connectionism, and dynamic systems theory, and concluding with a critique of the cognitive science approach.

The second section focuses on learning theories, presenting contributions from the fields of philosophy, psychology, education, and computer science, and reviewing the major schools of thought on the nature of learning: behaviorism, cognitivism, and constructivism. The learning theory of cognitive constructivism (Papert, 1980/1999) underlies the Teaching for Understanding Framework (Perkins, 1998) used to develop the prototype learning modules. The final section focuses on individual approaches to learning and understanding including Gardner's Theory of Multiple Intelligences (Gardner, 1983/1993) on which Multi-Intelligent Online Learning is based.

Figure 1 Theoretical Foundation in Educational Psychology



Models of Thinking from Cognitive Science

The field of cognitive science is defined as the interdisciplinary study of mind and intelligence, which attempts to further our understanding of intelligent activities and the nature of thought (Audi, 1995). The major contributing disciplines to the field include philosophy, psychology, computer science, linguistics, neuroscience, and anthropology. The intellectual foundation for the field originated in the mid-1950s when researchers in several fields worked on the development of theories of mind employing complex representations and computational procedures.

History of Cognitive Science

Initial attempts to understand thought processes and the mind are documented in the work of such ancient Greek philosophers as Plato and Aristotle. From these origins, the study of the mind was seen as strictly the purview of philosophers. In 1879, Wilhelm Wundt, a German philosopher and psychologist, established the first experimental psychology laboratory (Plucker, 1998). Considered to be the father of experimental psychology and the founder of modern psychology, Wundt pioneered in a systematic examination of mental operations, describing mental events in terms of both objectively measurable stimuli and responses and introspective accounts by subjects. Later psychological research laboratories were modeled after the one developed by Wundt.

By the early 1950s, both the logical positivism in vogue in the field of philosophy and behaviorist theory then prevalent in the field of psychology questioned the value of systematic inquiry into the operation of the mind (Thagard, 1996). Behaviorists such as John Watson held the view that psychologists should only examine observable phenomena and should focus on conducting stimulus/response experiments. This brought an end (fortunately a temporary one) to the discussion of mental representations and the mind, particularly among psychologists.

Between the mid-1950s and the early 1970s, each of the contributing disciplines to the field of cognitive science moved away from logical positivist and behaviorist approaches. In 1956, George Miller demonstrated capacity limits in human thinking, including a limit of approximately seven items that can be held in short-term memory (Miller, 1956). Miller observed that people

overcome this limitation in short-term memory by employing chunking, a process of recoding information into manageable groups. Thus, Miller posited the existence of mental representations, supporting the procedures people use to encode and decode chunks of information. A parallel development in the field of linguistics was the development by Noam Chomsky of a set of rules to explain human understanding of language (Chomsky, 1957). In this way, Chomsky rejected behaviorist claims that language is merely a learned habit.

The introduction of computers capable of manipulating information supported the process of theorizing about information in an abstract manner. Research in artificial intelligence by John McCarthy (1959), Marvin Minsky and Seymour Papert (1969), Allen Newell and Herbert Simon (1972), and others supported the premise that machines could process information and behave in a way that demonstrated intelligence. Through these and other developments in each of the underlying disciplines, the foundation was laid for cognitive science.

By 1985, the field of cognitive science was sufficiently accepted for a respected cognitive psychologist, Dr. Howard Gardner, to publish an overview of the history and development of the field. In his book, entitled *The Mind's New Science: A History of the Cognitive Revolution*, Gardner defines cognitive science as "a contemporary, empirically based effort to answer long-standing epistemological questions – particularly those concerned with the nature of knowledge, its components, its sources, its development, and its deployment" (Gardner, 1985, p. 6). While some cognitive scientists study intelligent activities performed by both machines and people, Gardner and other cognitive scientists recommend that the domain of cognitive science focus on an examination and explanation of human ways of knowing.

Three major approaches to modeling thinking have been developed in the field of cognitive science (Eliasmith, 1998).

Symbolicism or Classicism

Symbolicism, or what is now referred to as Classicism, employs symbolic processing to model thought processes. The work of Allen Newell and Herbert Simon (1972) represents an early attempt to model human problem solving using symbolic processing. The early research efforts of Noam Chomsky (1957) on syntactic structures, Marvin Minsky and Seymour Papert

(1969) in artificial intelligence, Jerry Fodor on the language of thought (1975), and Zenon Pylyshyn (1973) on visual perception are all based on the use of symbolic processing to construct models of human behavior.

Connectionism

The school of thought known as connectionism views thought processes as connections between nodes in a distributed network. Warren McCullough and Walter Pitts (1943) developed the first model of neural networks. D.O. Hebb (1949) conducted research in biological neural studies and is considered by many to be the father of cognitive psychobiology. In 1957, Frank Rosenblatt invented the Perceptron at the Cornell Aeronautical Laboratory (Rosenblatt, 1958). In 1960, Rosenblatt demonstrated learning by a machine when the Mark I Perceptron "learned" to recognize and identify optical patterns. However, after Minsky and Papert's analysis of the limitations of the Perceptron work (1969), most research in the area of connectionism ceased. *In Parallel distributed processing: Explorations in the microstructure of cognition,* Rumelhart and McClelland (1986) re-introduced connectionist computational models into cognitive science research after a hiatus of approximately fifteen years.

Dynamic systems theory

The theoretical approach referred to as dynamic (or dynamical) systems theory uses differential equations to describe a multidimensional space of potential thoughts and behaviors, traversed by a path of thinking followed by an agent under certain environmental and internal pressures. Some cognitive scientists view dynamic systems theory as a promising approach to modeling human thinking. In *The Dynamical Hypothesis in Cognitive Science* (van Gelder, 1998), Tim van Gelder presents the view that cognitive agents may well be dynamical systems rather than computational systems.

Critique of Cognitive Science

In *Connectionism and Cognitive Architecture: A Critical Analysis*, Fodor and Pylyshyn (1988) argue that both connectionist and classical architectures posit the existence of representational mental states but only classical architectures offer a symbolic level of representation. According to their paper, a symbolic level of representation is necessary to

support productive and systematic thought as well as symmetries exhibited by cognitive capacities that allow thoughts with semantically related contents to be tied together. Therefore, they argue that the architecture of the mind/brain is not connectionist on the cognitive level.

However, Minsky (1990) believes that the schism between symbolic and connectionist approaches is wrong and that multiple representations are needed to model intelligent behavior. In his paper *Logical vs. Analogical or Symbolic vs. Connectionist or Neat vs. Scruffy*, Minsky argues that "to solve really hard problems, we'll have to use several different representations. This is because each particular kind of data-structure has its own virtues and deficiencies, and none by itself seems adequate for all the different functions involved with what we call 'common sense'" (Minsky, 1990, p. 4). In *Society of Mind*, Minsky discusses the meaning of meaning and states that "the secret of what something means lies in how it connects to other things we know. That's why it's almost always wrong to seek the 'real meaning' of anything. A thing with just one meaning has scarcely any meaning at all" (Minsky, 1985, p. 64). Therefore, Minsky suggests that "in order to get around these constraints, we must develop systems that combine the expressiveness and procedural versatility of symbolic systems with the fuzziness and adaptiveness of connectionist representations. (Minsky, 1990, p.4). According to Minsky, researchers have been attempting to oversimplify their models of thinking. Minsky now believes that "to solve typical real-world commonsense problems, a mind must have at least several different kinds of knowledge. First, we need to represent goals: what is the problem to be solved. Then the system must also possess adequate knowledge about the domain or context in which that problem occurs. Finally, the system must know what kinds of reasoning are applicable in that area. Superimposed on all of this, our systems must have management schemes that can operate different representations and procedures in parallel" (Minsky, 1990, p.5).

Gardner (1985) lists several different issues raised by critics of cognitive science:

- There have been many models of human cognition, including the switchboard, the hydraulic pump, and the hologram. Many critics believe that it is a mistake to consider human beings to be systems that process information. Such critics are

skeptical of the computer providing any better model for human cognition than previous failed models (Gardner, 1985).

- Anthropologists contend that historical and cultural factors affect human cognition and are not included in computational models (Gardner, 1985).
- Some critics believe that cognitive science cannot succeed unless the field addresses factors such as affect, history, and context, which impact human thinking (Gardner, 1985).
- Behaviorists criticize the representational view and believe that the focus should be on observable behaviors and neurological structures (Gardner, 1985).
- The interdisciplinary approach adopted by cognitive scientists is seen by some critics as an ineffective way to advance the research effort. These critics recommend that each discipline clarify its own individual approach rather than expending energy on trying to work with members of other disciplines (Gardner, 1985).
- Neuroscientists believe that mental representations are unnecessary since the brain provides its own model. Therefore, we can use ordinary language and the nervous system itself, without the need for an intermediary model of the thinking process (Gardner, 1985).
- At the same time, major disagreement exists about the applicability of brain science to cognitive science (Gardner, 1985).
- Philosophers Hubert Dreyfus and John Searle, though they vehemently disagree with each other on other points (Dreyfus, 1999) argue that the claim that human minds work by representation and computation is fundamentally wrong.

Learning Theories

Influence of Postmodernism

Starting in the period of the Enlightenment, Modernity offered a worldview based on using rational, empirical, and objective approaches to discern the truth (Wilson, 1997). Structuralism arose in the 1960s in France as an attempt to synthesize the approaches of structural linguistics, Marxism, and the psychoanalytic movement. According to structural linguistics, developed by

Ferdinand de Saussure (1857-1913), meaning comes not from analyzing individual words but from considering the structure of a whole language. According to Karl Marx (1818-1883), truth can be discerned by analyzing economic structures. According to the psychoanalytic movement begun by Sigmund Freud (1856-1939), the structure of an individual's psyche can be understood through an examination of the unconscious. The term structuralism is credited to anthropologist Claude Levi-Strauss (1908-), who applied models of linguistic structure to the study of the customs and myths of society as a whole. Believing that individuals do not control the linguistic, sociological, and psychological structures that shape them, structuralists moved away from the existentialist view that individuals are what they make themselves. However, according to the structuralist worldview, the structures that shape individuals can be uncovered through systematic investigation.

Post-structuralism and deconstruction arose in reaction to structuralism and can be considered to be the foundation of postmodernism. Postmodernism is based on a belief in the plurality of meaning, perspectives, methods, and values, and an appreciation of alternative interpretations. Postmodernists distrust theories that purport to explain why things are the way they are, believing in the existence of multiple truths based on various perspectives and ways of knowing (Wilson, 1997).

Contributions from Philosophy, Psychology, Education, and Computer Science

The work of various philosophers, psychologists, educators, and computer scientists constitutes the foundation for the development of learning theories. This section provides a brief summary of the contributions from each of these fields to theories of learning. The summary descriptions are provided in order of the date of birth of each notable contributor.

John Dewey (1859-1952).

Dewey, an American philosopher and educator, is considered to be the father of progressive education in America (Dewey, 1938/1963). During his graduate education in philosophy, Dewey was exposed to the organic model of nature based on German idealism by George Sylvester Morris. At the same time, Dewey developed an appreciation of a scientific approach to human sciences through his work with G. Stanley Hall, a prominent American

experimental psychologist. Dewey was influenced by Darwin's work on evolution and believed that the development of knowledge begins as an adaptive human response to the environment that is intended to actively restructure environmental conditions.

Whereas traditional theories of knowledge considered thought to be a subjective primitive out of which knowledge is composed, Dewey considered thought to be the product of the interaction between an organism and the environment and knowledge, guiding and controlling the interaction between the organism and the environment. Thus, Dewey applied the term "instrumentalism" to his naturalistic understanding and philosophy. Dewey believed that organisms interact with the world through self-guided activity, thereby coordinating and integrating sensory and motor responses rather than passively reacting to stimuli. Identifying his views with the school of pragmatism founded by William James (1842-1910), Dewey's theory of knowledge encompassed a view of the world as one in which active manipulation of the environment is involved throughout the process of learning.

Based on his philosophy of instrumentalism, Dewey rejected the practice of rote learning, the common mode of instruction at the time. Throughout his professional career as well as during his retirement, Dewey wrote extensively on education. Some of his books on education include: *My Pedagogic Creed* (1897), *The School and Society* (1900), *Child and the Curriculum* (1902), *Democracy and Education: An Introduction to the Philosophy of Education* (1916), *How We Think: A Restatement of the Relation of Reflective Thinking to the Educative Process* (1933), and *Experience and Education* (1938). According to Dewey, students learn by "directed living" (Dewey, 1938/1963); thus, his educational approach emphasized workshop-type activities in which students learn through active participation in relevant projects.

Jean Piaget (1896-1980).

Jean Piaget was a Swiss psychologist and pioneer in the study of development of cognitive function in children. The goal of Piaget's research in developmental psychology and genetic epistemology was to understand how knowledge develops. Through his research, Piaget postulated that knowledge develops through a progressive construction of logically embedded structures. These structures supersede one another by incorporating less powerful logical means

into more powerful means as a child matures. Based on this progression, Piaget felt that children's logic and modes of thinking differ from those of adults (Piaget & Inhelder, 1969).

The cognitive development theories Piaget developed became the founding principles of the constructivist movement. According to Piaget's theory, there are four levels of cognitive development (Piaget & Inhelder, 1969):

- Sensorimotor (0-2 years) – intelligence develops through movement and other sensory experiences.
- Preoperational (2-6 years) – intelligence develops through the use of pictures, words, and other symbols to represent objects and concepts.
- Concrete operational (6-11 years) – cognitive development includes logic as long as logic is applied to specific physical examples.
- Formal operational (11+ years) - thinking matures to include the ability to understand and develop abstract concepts. At this stage, children (and adults) are capable of logical and abstract thinking without the need for physical examples on which to base their abstract ideas.

Piaget's theory of cognitive development postulates that learning occurs through adaptation to interactions with the environment (Piaget & Inhelder, 1969). When mental conflict arises from the occurrence of a new experience, a state of disequilibrium exists. Since disequilibrium demands some type of resolution, one of two reactions occurs. A process Piaget referred to as assimilation occurs with some entirely new experiences; through assimilation, individuals add new experiences to their existing base of knowledge. With other new experiences, accommodation occurs, thereby modifying an individual's existing understanding.

Lev Vygotsky (1896-1934).

Vygotsky, a Russian psychologist, applied a sociocultural approach to cognitive development, emphasizing the fundamental role of social interaction in the development of cognition (Cole & Wertsch, 1996). Vygotsky's theory postulated two levels of learning, with the first level occurring through interaction with others and the second level integrating knowledge into an individual's mental structure. Vygotsky suggested that an experienced peer or teacher

serve as a partner in the learning experience, providing an overall framework or "scaffolding" of subject matter to support the development of a student's understanding. Vygotsky also postulated that a "zone of proximal development" exists and is an area of exploration for which a student is cognitively prepared (Cole & Wertsch, 1996). However, in order for cognitive development to occur, the student must engage in social interaction with an experienced teacher or peer.

Nelson Goodman (1906-1998).

Goodman, an American philosopher, developed a constructivist philosophy that he referred to as a philosophy of understanding (Goodman, 1978). In his book entitled *Actual Minds, Possible Worlds*, Jerome Bruner includes an essay on Nelson Goodman's worlds (Bruner, 1986). According to Bruner, Goodman's "central thesis, 'constructivism,' is that contrary to common sense there is no unique 'real world' that preexists and is independent of human mental activity and human symbolic language" (Bruner, 1986, p.95). According to Goodman's concept of worldmaking, "what we call the world is a product of some mind whose symbolic procedures construct the world" (Bruner, 1986, p.95).

Jerome Bruner (1915-).

Jerome Bruner, a cognitive psychologist and educator, developed a cognitive learning theory based on the concept of categorization (Bruner, Goodnow, & Austin, 1956). According to Bruner's theory, the acts of perceiving, conceptualizing, learning, and decision-making all entail categorizing. Bruner postulates that people interpret the world in terms of similarities and differences among various events and objects. While engaged in categorizing, people employ a coding system based on a hierarchical arrangement of categories that are related to each other, with each level being successively more specific.

Bruner focuses on the formation of these coding systems in his cognitive learning theory (Bruner, Goodnow, & Austin, 1956). These coding systems serve to facilitate transfer of knowledge, increase retention of information, and improve motivation and problem solving skills. Based on his cognitive learning theory, Bruner is a strong proponent of discovery oriented learning methods in schools (Bruner, 1960, 1996). These educational methods assist students in discovering relationships between categories.

Michel Foucault (1926-1984).

Michel Foucault was a French philosopher and historian, who has come to represent the post-structuralist movement (Foucault, 1970/1994). While Foucault believed that rule-governed systems shape language and society, he did not believe in the existence of definite underlying structures that explain the condition of individuals. Another fundamental belief held by Foucault is that it is impossible to survey a situation objectively since one cannot step outside of the discourse. Challenging the views of the existence of underlying structures promoted by Marx and Freud, Foucault believed that there is no ultimate truth to be uncovered. Rather, everyday practices allow people to develop a systematic view of knowledge and to define who they are. As an historian, Foucault moved away from a view of history as containing a set of inevitable facts, and instead focused on studying the shifting patterns of power and the underlayers of knowledge. Seeking to perform what he referred to as an archaeology of knowledge, Foucault sought to demonstrate the development of knowledge as intertwined with mechanisms of political power, analyzing speech acts in terms of their history rather than in terms of their absolute truth. Believing that no deep underlying truth or structures exist, Foucault viewed the search for knowledge as an active process of shaping and creating objects rather than as a quest to uncover pre-existing objects.

Seymour Papert (1928-).

Seymour Papert and Marvin Minsky, pioneers in artificial intelligence, established the MIT Artificial Intelligence Laboratory in the early 1960s (Papert, 1996). Before Papert went to MIT, he worked with Jean Piaget at the University of Geneva from 1958 to 1964. Working with Piaget, Papert decided to employ mathematics to understand how children think and learn. In his early research, Papert sought to explain the results of Piaget's experiments with children. Most previous theories suggested that children develop more sophisticated types of reasoning skills as they grow up. Papert, on the other hand, recognized a difference not only in the reasoning skills of the children as they grew but also a difference in the organization of knowledge by the children as they matured. In *The Society of Mind*, Minsky refers to this concept as Papert's Principle, stating that "some of the most crucial steps in mental growth are based not simply on acquiring

new skills, but on acquiring new administrative ways to use what one already knows" (Minsky, 1985, p. 102).

Through Papert's work in educational computing, he is considered to be a cognitive constructivist (Chen, 2000). Papert contrasts behavioral approaches to teaching that break down knowledge to be learned into individual pieces with holistic, authentic teaching methods used in constructivist approaches.

Jacques Derrida (1930-).

Derrida, a French philosopher, developed deconstruction as an analytical method to uncover multiple interpretations of text (Rorty, 1995). In 1967, Derrida published *Speech and Phenomena*, *Of Grammatology*, and *Writing and Difference*, introducing the deconstructive approach to reading texts. Derrida believes that all text is ambiguous; it is therefore impossible to have a complete and final interpretation. Influenced by Heidegger and Nietzshe, Derrida questions the Aristotelian laws of identity that "whatever is, is", that "nothing can both be and not be" and that "everything must be or not be" (Rorty, 1995). Derrida indicates that that there are differences, multiple interpretations, and ambiguities, not explainable by such a clear-cut logical view of the world. According to Derrida, most people believe that language is capable of expressing ideas without changing them and that the author of a text is the source of the meaning of that text. Drawing on psychoanalytic and linguistic approaches, Derrida uses deconstruction to challenge these assumptions and the belief that there is an unchanging, unified meaning to any text. Derrida contends that there are multiple legitimate interpretations of a text and that there are multiple layers of meaning at work in language. While Derrida's work focuses on language and literature, his strategy of analysis has been applied to the fields of philosophy, linguistics, law, and architecture.

Richard Rorty (1931-).

Richard Rorty, an American philosopher trained in the analytic tradition, is considered to be a neopragmatist, linking him with such American pragmatists as William James (1842-1910), psychologist, philosopher, and functionalist; Charles Peirce (1839-1914), philosopher, logician, and founder of pragmatism; and John Dewey (1859-1952), philosopher, educator, and

instrumentalist (Rorty, 1979). Similar to the pragmatist view, Rorty believes that as humans, we constantly redefine our world in order to make it work better for us. Rorty holds that the socially-described truth of statements about our world, our beliefs, and our opinions makes them meaningful. As a relativist, Rorty holds that human understanding is based on our interpretation of the world through a variety of paradigms rather than on an objective structure of the mind. Agreeing with other postmodernists that, as humans, we create ourselves and our worlds, Rorty believes that philosophers can facilitate the development of new metaphors to enable us to communicate the subjective truths we hold (Rorty, 1979).

Danah Zohar (1945-).

Zohar is an American philosopher who uses concepts from quantum physics to explain human consciousness (Zohar & Marshall, 1990, 1994, 2000). Since classical properties of matter are unlikely to give rise to consciousness, some philosophers look to quantum theory, which allows for a new concept of matter, to explain the existence of consciousness. Zohar bases her explanation of human consciousness on Bose-Einstein condensates, the most highly ordered structures in nature. Using the wave/particle duality, Zohar suggests that the wave aspect of nature yields mental constructs while the particle aspect of nature yields the material aspects of existence.

Behaviorism to Cognitivism to Constructivism

If we consider the question of what learning is and how it occurs, we can identify three major schools of thought on the nature of learning and the properties of knowledge. These three psychological theories differ in their perspectives on the way in which learning occurs. These approaches also differ in the properties they ascribe to knowledge, whether knowledge is given and absolute or constructed and relativistic.

Behaviorism.

Behaviorism, dominant in the 1950s and 1960s, focused on the observation of behavior and the adaptation of organisms to the environment. Early behavioral learning experiments consisted of stimulus/response experiments with animals. Ivan Petrovich Pavlov conducted a now-famous experiment in which he was able to make a dog salivate to the sound of the bell,

linking the sound of the bell to the anticipation of food. Burrhus Frederic (B.F.) Skinner, one of the leaders of the behavioral psychology movement, developed the “Skinner box” to test the reactions of pigeons to specific stimuli. Though most behaviorist experiments were conducted on reflexive behavior of animals, behaviorist theories were generalized to higher-level functions of humans. According to behaviorist learning theories, learners are viewed as adapting to the environment. There is no interest in or discussion of mental processes in behaviorist approaches to learning. Thus, learning is considered to be primarily a passive and reactive process, with learners responding to the expectations and requirements of the environment. Behaviorist learning theories view knowledge as objective, given, and absolute (Graham, 2000).

Cognitivism.

Developers of cognitivist learning theories were frustrated by the behaviorist restrictions to purely observable phenomena. In the opinion of the cognitivists, such constraints limited the applicability of behaviorist learning theories. Cognitivist learning theories moved away from stimulus/response experiments, delving into the mental processes of learners and developing approaches to model acts of thinking and learning. As discussed earlier in this paper in the section on models of thinking from cognitive science, cognitivist theories view knowledge as symbolic, mental constructions. These mental constructions can be found in the minds of individuals. With this model of thinking, learning consists of building symbolic frameworks, processing abstract representations of thoughts, and incorporating these representations into memory. Adopting a model based on the input-output information processing architecture of digital computers, cognitivism employs an information processing approach to learning (Gardner, 1985).

Thus, cognitivist learning theories moved away from behaviorist assumptions that learners passively adapt to their environment. Though cognitivist learning theories are based on active mental processing on the part of learners, such theories still maintain the behaviorist perspective on knowledge, considering knowledge to be both given and absolute.

Constructivism.

Whereas the behaviorist school views knowledge as passive, primarily automatic responses to stimuli in the environment, and the cognitivist school views knowledge as abstract symbolic representations in the minds of individuals, the constructivist school views knowledge as a constructed entity developed by each individual learner (Houghton Mifflin, 2001). According to constructivist theory, information is transmitted but knowledge cannot be transmitted from teacher to student, parent to child, or any one individual to another; rather, knowledge is (re)constructed by each individual in his/her own mind. This is a fundamental difference from the view of knowledge as given and absolute held by behaviorists and cognitivists. Moreover, constructivists consider knowledge to be relative, varying through time and space.

According to constructivist theory, nothing is absolute, and nothing can be considered as given. Learning is considered to be the result of an individual's mental construction. Individuals learn by actively constructing their own understanding, incorporating new information into the base of knowledge they have already constructed in their own minds. In addition, the context of the learning experience and the beliefs and attitudes of the learner affect his/her learning.

Constructivist learning situations are set up to encourage learners to invent their own solutions and to actively engage in testing out their hypotheses and ideas, building on their prior knowledge. Based on the research of Jean Piaget, constructivist theory disagrees with the traditional view that knowledge has an existence of its own apart from the minds of individuals. The theory, differing from earlier views that the mind is a tabula rasa, a blank slate on which learning is painted, holds that students learn through active participation in relevant and engaging critical thinking and problem-solving tasks.

While there are various schools of thought within constructivism, the two major theoretical approaches emanate from cognitive constructivism and social constructivism (Chen, 2000). Cognitive constructivists postulate that learning occurs as a result of the exploration and discovery by each individual learner. In the view of cognitive constructivists, knowledge is a symbolic, mental representation in the mind of each individual. Stressing the collaborative efforts

of groups of learners as sources of learning, social constructivists consider the mind to be a distributed entity extending beyond the bounds of the human body into the social environment.

Individual Approaches to Learning and Understanding

While differences of opinion abound regarding the cause and methods for handling individual differences in learning and understanding, most professionals now concur on the existence of individual approaches. In this section, we explore different frameworks for describing individual approaches to learning and understanding as well as a dissenting perspective that views intelligence as a single, measurable phenomenon.

Two major approaches that offer an explanation for differences in thinking among various individuals are:

- The cognitive psychology approach developed by Howard Gardner in his Theory of Multiple Intelligences.
- The development of distinct types and profiles of thinking styles by Robert Sternberg, leading to what Sternberg refers to as successful intelligence.

A dissenting view by Arthur Jensen considers intelligence to be a single, monolithic, general mental ability in humans.

Theory of Multiple Intelligences

The cognitive theory that each individual possesses multiple intelligences rather than one single intelligence is presented in Howard Gardner's seminal work, *Frames of Mind: The Theory of Multiple Intelligences* (Gardner, 1983/1993). In *Frames of Mind*, Gardner explains the need for a theory of cognition that encompasses various distinct human faculties. In *Intelligence Reframed: Multiple Intelligences for the 21st Century* (Gardner, 1999), Gardner offers an updated definition of an "intelligence". Gardner considers an intelligence to be "a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture" (Gardner, 1999, pp. 33-34).

Gardner then uses this definition along with evidence from the fields of psychology, biology, and anthropology to delineate eight criteria, which are used to determine the specific human intelligences.

From the biological sciences, Gardner finds two determining factors for intelligences:

- "the potential of isolation by brain damage"
- "an evolutionary history and evolutionary plausibility" (Gardner, 1999, p. 36).

Based on logical analysis, Gardner identifies two other criteria:

- "an identifiable core operation or set of operations"
- "susceptibility to encoding in a symbol system" (Gardner, 1999, pp. 36-37).

Developmental psychology adds two more criteria:

- "a distinct developmental history, along with a definable set of expert 'end-state' performances"
- "the existence of idiot savants, prodigies, and other exceptional people" (Gardner, 1999, pp. 38-39).

The last two criteria for determining separate intelligences are based on traditional psychological research:

- "support from experimental psychological tasks"
- "support from psychometric findings" (Gardner, 1999, p. 40).

Based on these eight criteria, Gardner posits the existence of eight separate human intelligences. Gardner defines these intellectual capacities as follows.

- Linguistic intelligence: "Linguistic intelligence involves sensitivity to spoken and written language, the ability to learn languages, and the capacity to use language to accomplish certain goals" (Gardner, 1999, p. 41).
- Logical-mathematical intelligence: "Logical-mathematical intelligence involves the capacity to analyze problems logically, carry out mathematical operations, and investigate issues scientifically" (Gardner, 1999, p. 42).
- Musical intelligence: "Musical intelligence entails skill in the performance, composition, and appreciation of musical patterns" (Gardner, 1999, p. 42).
- Bodily-kinesthetic intelligence: "Bodily-kinesthetic intelligence entails the potential of using one's whole body or parts of the body (like the hand or the mouth) to solve problems or fashion products" (Gardner, 1999, p.42).

- Spatial intelligence: “Spatial intelligence features the potential to recognize and manipulate the patterns of wide space (those used, for instance by navigators and pilots) as well as the patterns of more confined areas (such as those of importance to sculptors, surgeons, chess players, graphic artists, or architects)” (Gardner, 1999, p.42).
- Interpersonal intelligence: “Interpersonal intelligence denotes a person’s capacity to understand the intentions, motivations, and desires of other people and, consequently, to work effectively with others” (Gardner, 1999, p.43).
- Intrapersonal intelligence: “Intrapersonal intelligence involves the capacity to understand oneself, to have an effective working model of oneself – including one’s own desires, fears, and capacities – and to use such information effectively in regulating one’s own life” (Gardner, 1999, p. 43).
- Naturalist intelligence: “expertise in the recognition and classification of the numerous species – the flora and fauna – of his or her environment” (Gardner, 1999, p. 48).

According to Gardner’s Theory of Multiple Intelligences, these intelligences are both biological and learned or developed. Though everyone possesses all eight of these intelligences, individuals differ in terms of which of their intelligences are more developed than the others.

Thinking Styles and Successful Intelligence

Robert Sternberg delineates three aspects of successful intelligence: analytical, creative, and practical. “Successful intelligence is most effective when it balances all three of its analytical, creative, and practical aspects. It is more important to know when and how to use these aspects of successful intelligence than just to have them. Successfully intelligent people don’t just have abilities, they reflect on when and how to use these abilities effectively” (Sternberg, 1996, p. 128).

Sternberg’s approach to variation in thinking and learning is to consider a person’s thinking styles. Sternberg defines a *style* as “a way of thinking. It is not an ability, but rather, a preferred way of using the abilities one has. The distinction between style and ability is a crucial one. An ability refers to how well someone can do something. A style refers to how someone likes to do something” (Sternberg, 1997, p. 8). Gardner also distinguishes between intelligences and

styles. According to Gardner, an individual can apply the same general approach, i.e. the same style, to various types of content whereas the component processes that constitute an intelligence apply to specific content, such as spatial patterns or musical sounds (Gardner, 1995).

Sternberg considers his theory of styles to be "a *theory of mental self-government*" (Sternberg, 1997, p. 148). He elaborates on his theory by organizing thinking styles into five descriptive categories. According to his theory, "*people have profiles (or patterns) of styles, not just a single style*" (Sternberg, 1997, p. 83). The five categories are as follows:

- Functions: legislative, executive, and judicial. These styles characterize the way in which various people prefer to approach and perform necessary tasks in their thinking and working.
- Forms: monarchic, hierarchic, oligarchic, and anarchic. Form characterizes the overall manner in which a person approaches the world.
- Levels: global and local. The level of thinking style describes whether a person prefers a "big picture" perspective or a detail-oriented view.
- Scope: internal and external. The concept of scope characterizes people's thinking in terms of a preference to think and solve problems in isolation, or a social awareness and preference to work with other people.
- Leanings: liberal and conservative. Leanings describe a person's preference in terms of structure, change, and ambiguity. A liberal thinking style suggests that a person prefers less structure and readily accepts change and ambiguity, whereas a conservative thinking style expresses a person's preference for established rules and procedures and a discomfort with change or ambiguity.

Sternberg offers self-activation strategies that lead to successful intelligence. These can be described in terms of the characteristics and attributes of successfully intelligent people.

According to Sternberg, successfully intelligent people:

- "motivate themselves" (Sternberg, 1996, p. 251).
- "learn to control their impulses" (Sternberg, 1996, p. 255).
- "know when to persevere" (Sternberg, 1996, p. 256).

- "know how to make the most of their abilities" (Sternberg, 1996, p. 257).
- "translate thought into action" (Sternberg, 1996, p. 258).
- "have a product orientation" (Sternberg, 1996, p. 259).
- "complete tasks and follow through" (Sternberg, 1996, p. 260).
- "are initiators" (Sternberg, 1996, p. 261).
- "are not afraid to risk failure" (Sternberg, 1996, p. 261).
- "don't procrastinate" (Sternberg, 1996, p. 262).
- "accept fair blame" (Sternberg, 1996, p. 263).
- "are independent" (Sternberg, 1996, p. 264).
- "focus and concentrate to achieve their goals" (Sternberg, 1996, p. 265).
- "spread themselves neither too thin nor too thick" (Sternberg, 1996, p. 266).
- "have the ability to delay gratification" (Sternberg, 1996, p. 266).
- "have the ability to see the forest and the trees" (Sternberg, 1996, p. 266).
- "have a reasonable level of self-confidence and a belief in their ability to accomplish their goals" (Sternberg, 1996, p. 267).
- "balance analytical, creative, and practical thinking" (Sternberg, 1996, p. 268).

The g Factor

Contrary to Gardner's Theory of Multiple Intelligences, Arthur Jensen believes that there exists a single, monolithic, general mental ability in humans. This general mental ability is referred to as *g*. Jensen supports his theory of a single measurable intelligence with psychometric results, stating that he is providing empirical evidence for what Charles Spearman initially discovered in the 1920s. Continuing the work begun by Spearman, Jensen states that "the fact that *g* can be extracted in a hierarchical analysis from any large and diverse battery of mental tests itself proves the existence of *g*, at least on the level of factor analysis" (Jensen, 1998, p. 106). While Jensen considers Sternberg's theory as not antithetical to *g* theory, Jensen argues that "a consideration of several sources of evidence used by Gardner to establish the existence of independent intelligences may be used to support the existence of a superordinate general intelligence factor" (Jensen, 1998, p.130). While Jensen states that intelligence tests prove the existence of one

single fixed inherited capacity, the researcher's experience with learners supports Gardner's Theory of Multiple Intelligences. In online learning environments, it is important to shift from a view of intelligence based on a fixed monolithic capacity to one that focuses on learnable behavior through multiple intellectual capabilities.

While useful in explaining behavior patterns in individuals and helping people understand and modify their behaviors to achieve more successful outcomes, Sternberg's theory is not supported by convincing biological and psychological evidence as Gardner's theory is. The crux of Jensen's argument is that statistical evidence proves the existence of a single intelligence. However, Jensen uses these statistics to argue his case, while at the same time basing his case on the statistical evidence he has developed. This then becomes a circular argument.

Further, Gardner's theory has been successfully applied in learning situations in schools. In addition, educational methodologies have been developed based on Multiple Intelligence Theory, and have been used and tested over a period of years. There is concrete evidence demonstrating the success of teaching and learning experiences in classroom situations that are based on Multiple Intelligence Theory. The successful application of Multiple Intelligence Theory in classroom environments paves the way for successfully applying the theory to an online learning environment.

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