McGill Journal of Education
Revue des sciences de l'éducation de McGill

Metaphor, Paradigm, and Education
MÉTAPHORE, PARADIGME ET ÉDUCATION

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Volume 52, Number 1, Winter 2017

URI: https://id.erudit.org/iderudit/1040803ar
DOI: https://doi.org/10.7202/1040803ar

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Publisher(s)

Faculty of Education, McGill University

ISSN

1916-0666 (digital)

Explore this journal

Cite this article

Ivie, S. D. (2017). Metaphor, Paradigm, and Education. *McGill Journal of Education / Revue des sciences de l'éducation de McGill*, *52*(1), 33–51. https://doi.org/10.7202/1040803ar

Article abstract

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METAPHOR, PARADIGM, AND EDUCATION

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ABSTRACT. Metaphor is a critical tool for thought. Lying at the heart of every systematic body of knowledge are three root metaphors — mechanism, organism, and mind. Historically, schools of philosophy — realism, naturalism, and idealism — have grown up around these metaphors. The root metaphors and their corresponding philosophies provide the paradigms underlying different exemplars of education. To illustrate how metaphors, paradigms, and exemplars all shape educational thought, the works of three educators — Hunter, Piaget, and Bruner — have been selected.

MÉTAPHORE, PARADIGME ET ÉDUCATION

RÉSUMÉ. La métaphore constitue un outil fondamental de la pensée. En effet, trois métaphores dites radicales sont au cœur de chacun des systèmes de connaissances structurés : la métaphore mécanique, la métaphore organique et la métaphore spirituelle. Au cours de l'Histoire, le développement de certaines écoles de philosophie telles que le réalisme, le naturalisme et l'idéalisme s'est fait autour de ces métaphores. Les métaphores radicales et les philosophies qui leur sont associées sont à la base des paradigmes autour desquels s'articulent les différents modèles éducationnels. Les travaux de trois théoriciens de l'éducation — Hunter, Piaget et Bruner — ont été choisis pour illustrer la manière dont les métaphores, les paradigmes et les modèles façonnent la pensée pédagogique.

Jose Ortega y Gasset (1925/1980) tells us, "The metaphor is probably the most fertile power possessed by man" (p. 784). Metaphor adds life and color to language. It expands our imaginations. Lakoff and Johnson (1980) have graphically described the universal appeal of metaphor. They support the thesis that most thought is metaphorical: "Metaphor is pervasive in everyday life, not just in language but in thought and action" (p. 3). Metaphor is not merely the language of poetry and religion: "What a piece of work is man"; or "God created the heavens and the earth." Metaphor is intimately interlaced with the various academic disciplines or paradigms of thought. Philosophy and quantum physics are both haunted by Plato's metaphor of the cave. Psychology and education are equally addicted to the Skinner box. American political and economic thought have kept alive the mechanistic language of the Enlightenment.

Metaphor has been instrumental in shaping the fabric of western thought. Pepper (1972) presented a persuasive case for how root metaphors mold our thinking. There is a simple root metaphor — mechanism, organism, or mind — lying at the heart of every intellectual paradigm: "a world hypothesis is determined by its root metaphor" (p. 96). Root metaphors are useful tools for analyzing abstract systems of ideas. They act as keys for "unlocking the doors of those cognitive closets which constitute the literature of structural hypotheses in philosophy and science" (p. 149). Identifying root metaphors is an essential step in coming to understand paradigms.

Kuhn's (1970) book, *The Structure of Scientific Revolutions*, has become a modern-day classic in the philosophy of science. Kuhn popularized the ideas of paradigms, paradigm shifts, and exemplars. "A paradigm is an accepted model or pattern" of ideas, around which an intellectual community organizes its thinking (p. 23). A paradigm shift occurs whenever an intellectual community rejects a "time-honored scientific theory in favor of another" (p. 6). Exemplars are the relevant examples that make up and help to define the paradigms.

There have been six principal paradigms in the history of western civilization. The first came with Aristotle's synthesis of Greek and classical knowledge. The second was created by St. Thomas Aquinas, who is credited with creating scholasticism. St. Thomas Aquinas' feat was one of fusing together Christian faith and Aristotelian logic. The third was Renaissance humanism, which emulated everything from classical Greece and Rome. The fourth paradigm reflected Newton's Law of Gravity. Newton envisioned the universe as one vast machine, like a perpetual motion clock. Other thinkers of the Enlightenment built their ideas around the same mechanistic paradigm. The fifth paradigm took the form of naturalism, which combined Rousseau's Romanticism with Darwin's evolution. The two paradigms might at first glance appear to be polar opposites; however, in the realm of education, many paradoxes often make for strange bedfellows. The sixth paradigm waited until the 20th century to make its appearance. Einstein's two theories of relativity and Heisenberg's interpretation of the data coming from quantum physics created two radically different views of reality. Relativity painted a picture of a universe governed by natural laws. Quantum mechanics, on the other hand, described the capricious behavior of subatomic particles. Einstein was sufficiently perturbed by Heisenberg's interpretation to cause him to declare: "God does not play dice with the universe." More recently, Hocking has retorted that not only does God play dice, but sometimes He throws them where they cannot be seen (Boslough, 1989, p. 35).

SCHOOLS OF PHILOSOPHY

Realism

The mechanistic metaphor underscores the philosophy or paradigm known as realism. The realist believes our senses inform us about a real world external to ourselves. Atoms, planets, and stars are all real; they are not illusions or figments of our imaginations. The real world of things exists whether we choose to recognize it or not. Newton did not invent the Law of Gravity; he discovered it. People cannot walk through fire without getting burned, turn water into wine, nor jump over tall buildings in a single bound. “As a physicist,” Weinberg (1992) tells us, “I perceive scientific explanations and laws as things that are what they are and cannot be made up as I go along” (p. 46).

Realism has had a distinguished scholarly history. John Locke, David Hume, and Bertrand Russell were all realists. They believed the most significant feature of the universe was its permanence. Although change occurs, it takes place in accordance with the laws of nature. Realists tend to favor the correspondence theory of truth, which asserts that an idea is true when it corresponds to some external object or event. Einstein is a good example of a scientist who believed in a lawful, deterministic universe. His search for a unified field theory was aimed at showing that underlying the capriciousness of quantum phenomenon there exists an orderly realm of subatomic particles.

Naturalism

The philosophical school of naturalism is based on the root metaphor of organism. Naturalism is one of the oldest continuing themes in western philosophy. It runs back to Thales of Miletus who believed everything was composed of one simple substance, water. Thales is significant because he offered a naturalistic explanation for existence. Naturalists believe nature is all that there is. Mankind is merely one more part of a purely natural world. There is no need to postulate supernatural explanations for events. If a giant earthquake were to sink California into the Pacific Ocean, it would be the result of movement in the tectonic plates and not the wrath of God. Naturalism leans heavily on the scientific method as the only legitimate method for arriving at truth. The foundations for this method were laid by Francis Bacon’s inductive logic, August Comte’s positivism, and Herbert Spencer’s Synthetic Philosophy. Butler (1957) said, “In Bacon, Comte, and Spencer, the rise of the modern scientific spirit is represented” (p. 89).

John Dewey, who is widely regarded as America’s premier philosopher, is a good example of a thoroughgoing naturalist. Dewey based his naturalism on two powerful ideas — Charles Darwin’s theory of evolution and William James’ functional psychology. Darwin likened nature to a living organism whose various parts work together to form an integrated whole. Humans, like plants and animals, must make an organic adaption to their ever-changing environment.

Dewey credited James with furnishing the "one specific philosophical factor which entered into my thinking so as to give it a new direction and quality" (as cited in Campbell, 1995, p. 33). Dewey (1916/1960) accepted James' functional psychology and expanded it into his theory of instrumentalism. Ideas are not copies of things in the world. They are tools for solving problems. "Mind is not a name for something complete by itself; it is a name for a course of action" (p. 155).

Idealism

Whitehead (1929/1957) once remarked, "The safest general characterization of the European philosophical tradition is that it consists of a series of footnotes to Plato" (p. 53). Plato (380 B.C./1968) was the founder of the philosophy or paradigm known as idealism, which rests squarely on the root metaphor of idea, mind, or soul. Idealists hold that the world we experience with our senses is merely one of appearances. Reality lies behind the world of physical appearances. The key to Plato's metaphysics is contained in his parable of the cave. Plato (380 B.C./1968) asked us to imagine a group of prisoners who are chained by the neck and the leg inside a cave. All they have ever seen are dancing shadows on the wall, cast by the light of a fire burning outside the entrance to the cave. Finally, one of the prisoners escapes from the cave and emerges into the light of day. At first the prisoner is blinded by the brilliance of the newly discovered world. In time the prisoner comes to see things as they really are. The story of the prisoner is symbolic of the journey of the soul as it seeks to know the absolute Forms (pp. 227-231).

Experimental science, when it emerged into the modern world, aligned itself with realism. Newton's physics favored such an alliance. Idealism, for a time, became a backroom theory kept alive by philosophers. This picture has now begun to change. The problems encountered by quantum physics and big bang theory suggest that Plato's philosophy deserves a second look. Afshordi, Mann, and Pourhasan (2014) contended that, "Plato was on to something. We may all be living in a giant cosmic cave, created in the very first moments of existence" (p. 38). The three physicists argued that, "This three-dimensional universe is merely the shadow of a world with *four* spatial dimensions" (p. 38). Our three-dimensional universe may be nothing more than a shell around a *four*-dimensional black hole. New questions, never entertained by Newton, have emerged. "What are dark matter and dark energy, and why do they make up 25 and 70 percent of the universe, respectively" (p. 40)? No one seems to know. The authors conclude by suggesting that if we assume a holographic model for the big bang, it "resolves not only the main puzzles of uniformity and near flatness of standard cosmology without resorting to inflation but also nullifies the damaging effects of the initial singularity" (p. 43). If the universe is merely a hologram, then clearly we are back inside Plato's cave.

COMPOSITE PHILOSOPHIES

Realism, naturalism, and idealism are all major metaphysical schools of thought. In addition to these philosophies, three composite philosophies have evolved over time (see Figure 1). These philosophies or paradigms — cyborgism, Romanticism, and dualism — combine two of the principal root metaphors. Cyborgism represents a synthesis of realism and naturalism. A cyborg is a person who possesses both mechanical and organic characteristics. Did you hear the one about Disney's new Pinocchio? He is a regular chip off the old block. Computer chips are found everywhere. Many people would be lost without their cell-phones, iPads or tablets. GPS is the universal traffic cop. Romanticism, on the other hand, combines naturalism and idealism. Many thought-provoking ideas have grown out of this synthesis. Romanticism became a major theme in 19th century literature. It had an equally profound effect on progressive education, which experienced great popularity between the two World Wars. Finally, dualism is a way of believing in realism and idealism at one and the same time. Humans are a prime example of a walking and talking dualistic reality. People are said to have immortal souls (idealism) inside their physical bodies (realism). Most Christians readily accept a dualistic metaphysics.

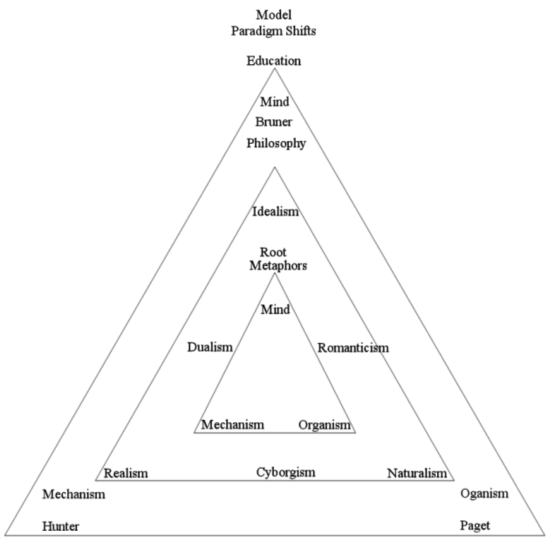

FIGURE 1. *Paradigm shifts*

Cyborgism

Scientists and physicians have not yet been successful in creating The Six Million Dollar Man. They are, however, working on it. Artificial limbs, which are aided by computer chips, are becoming more like biological limbs. Research on artificial intelligence is moving forward at a breakneck pace. If the human body is merely a biophysical machine, then the brain must be a computer. One of the more popular metaphors for thinking about the brain is to see it as an information processing device. "Human information-processing models," McCown, Driscoll, and Roop (1996) informed us, "borrow heavily from the vocabulary of the computer with terms such as input, output, storage systems, capacity, encoding, retrieval, and executive control" (p. 206). There is an inherent danger, however, in carrying the metaphor of the brain as a computer too far. Though we may begin by thinking that the brain is analogous to a computer, we may end by believing it really is a computer. Such an unchecked metaphor has the potential for causing untold damage in classrooms around the world.

It is time, said Markram (2012), we changed the way we study the brain. In the past, we have used a reductionist biological approach — examining individual brain parts, such as neural circuits and molecules — to understand the workings of the brain. Such an approach has fallen far short of taking us to our goal. A new paradigm that utilizes both analysis and synthesis is required. The various parts of the brain must be viewed within a working whole. The Human Brain Project does exactly that: "The key to our approach is to craft the blueprint according to which the brain is built" (Markram, 2012, p. 52). The project is designed to create, "a computer simulation of the 89 billion neurons inside our skull and the 100 trillion connections that wire those cells together" (p. 54). Such a copy of the human brain would allow research on cells and circuits within the brain.

Romanticism

Romanticism combines the naturalism of Francis Bacon with the philosophical idealism of Plato. The workings of the outer world are fused with those of the inner world. The principal figure responsible for accomplishing this new synthesis was Jean J. Rousseau (1712-1778), whose literary genius was one of moving the focus of philosophy away from the head and redirecting it toward the heart. Rousseau was a rebel who rejected the established conventions of his time. He wrote with passion and power, declaring in the *Social Contract*: "Man is born free, and everywhere he is in chains" (Rousseau, 1762/1955, p. 344a). Humans were meant to be free; they were meant to live in accordance with nature. Romantics' love for nature knew no bounds. They believed nature had within itself a mystical spirit of wisdom and goodness. Mankind could tune into this spirit through intuition. Feeling and emotion, not reason, would direct us toward the life of virtue. Thoreau (1854/1951) expressed his reverence for nature when he wrote in *Walden*: "I went to the woods because

I wished to live deliberately, to front only the essential facts of life, to see if I could not learn what it had to teach, and not, when I came to die, discover that I had not lived" (p. 421).

Dualism

Dualism is the wedding of realism and idealism. The person who was most responsible for the consummation of this marriage was the seventeenth century philosopher, Rene Descartes (1596-1650). According to Descartes, the world is composed of two different substances, material and spiritual. Material substances are subject to the laws of science; spiritual substances are ethereal and possess freedom of will. Humanity is a prime example of the two substances coming together. The body is a machine whose soul is the seat of consciousness. "'My soul,'" Descartes declared, "'is not in my body like a pilot in a ship'" (as cited in Urmson, 1965, p. 94). Rather, the soul is one with the body. The soul leaves the body when the body dies. Descartes believed the meeting place where the body and the soul came together was in the pineal gland, which had only recently been discovered in his time.

Descartes' division of the world into two radically different substances, material and spiritual, has never rested easily with realists. Gilbert Ryle's (1949) book, *The Concept of Mind*, set out to correct the linguistic problems inherent in Descartes dualism. Ryle contended that mind-body dualism is rooted in a misunderstanding of such mental states as willing, thinking, and imagining. Language tricks us into believing mind is an extraordinary substance controlling the body. Ryle referred to this belief as "the dogma of the ghost in the machine" (pp. 15-16). Mental concepts, properly understood, do not refer to ghostly acts but to dispositions to behave in certain ways. The whole dualist problem comes down to a category mistake, which occurs when we represent "the facts of mental life as if they belonged to one logical type of category (or range of types of categories), when they actually belong to another" (p. 16).

EDUCATION

Educational practices reflect their underlying philosophies or paradigms. This is clearly illustrated by the exemplars selected for further study — Hunter, Piaget, and Bruner (see Figure 1). Hunter was a realist who believed the business of education was principally one of helping each new generation of students master the proper subject matter. To accomplish this task, she believed teaching should be grounded in the sciences of psychology, neurology, and sociology. Hunter is best remembered for the instructional system she created outlining seven steps teachers should follow in their classroom presentations. Piaget was a naturalist who believed education was largely a matter of growth from within. The child's nature should serve as the guiding principle underlying all instruction. Piaget outlined four cognitive stages all children must necessarily pass through on their way to adult thinking. Bruner was a cognitive psychologist who believed in the primacy of mind. Bruner, Plato, and Kant all believed mind imposes categories and concepts on experience. Bruner encouraged educators to follow the spiral curriculum as a way of introducing students to the structure of knowledge.

Mechanism

Madeline Hunter's educational theories represent the first exemplar. They are in many ways similar to those of J. F. Herbart's, who was a 19th century German philosopher. Herbart greatly admired the scientific accomplishments of Newton. He wished to achieve similar scientific results in the fields of psychology and education. Herbart (as cited in Dunkel, 1969) dreamed of becoming the "Newton of the mind." Though Herbart came to occupy Kant's Chair at Konigsberg, he never accomplished for psychology and education what Newton had achieved for physics. He is best remembered for the instructional method that bears his name, Herbartianism (Dunkel, 1969, pp. 51-63).

Hunter (1916-1994) had a long and distinguished career. She held a variety of different positions in the field of education, including principal of the laboratory school and professor of education at UCLA. Hunter (1994) made it her life's work to translate the findings of psychology into the language of public school teachers, who she believed were ill-informed about the cause-effect relationships between teaching and learning. Her writings set out to clarify those relationships. Hunter's steps for effective teaching have been widely used by school districts around the United States.

There has been a long-standing debate in education: Is teaching an art or is it a science? Hunter (1984), like Herbart, came down on the side of science. "Teaching," she maintained, "is one of the last professions to emerge from the stage of 'witch doctoring' and become a profession based on a science of human learning" (p. 169). Why is teaching a science? Hunter's (1988) answer is clear and unequivocal: "We now know many cause-effect relationships in teaching and learning. As a result, we can use those causal relationships to promote student learning in the same way the doctor uses his medical knowledge to promote health" (p. 3).

Hunter (1984) maintained her theory of instruction is based on scientific research. Good teachers, she believes, are made not born: "The science of teaching can be taught and predictably learned by most professionals who are willing to expend the required effort" (p. 170).

Hunter (1988) acknowledged there is an artistic side to teaching: "If your teaching employs only science, you're a technologist. If your 'art' does not have a scientific foundation, you're a promising amateur. You need both art and science to be a master teacher" (p. 879). Art, however, is not where Hunter's interests reside. Art, she insisted, is based on intuition — something we do not know how to teach. Hunter clearly preferred speaking in scientific terms about teaching. Her writings are filled with technical jargon such as research-based theory, task analysis, input, performance-based objectives, diagnostic procedures, and assessment outcomes.

Hunter (1984) believed educators need to move away from making decisions based on intuition and cookbook recipes. Teaching should be based upon scientific research. Hunter (1984) stated, "Teaching is an applied science derived from research in human learning and human behavior: an applied science that utilizes the findings of psychology, neurology, sociology, and anthropology" (p. 171). She did not reveal how each of these disciplines contributes to the knowledge base underlying teaching, but she assured us research-based theory has now been translated into classroom practice "so we can describe and substantiate much of what is effective in teaching" (Hunter, 1984, p. 174).

Teaching, Hunter (1994) maintained, is the process of making and implementing decisions concerning instruction. All of the teachers' decisions have the aim of increasing the probability of learning: "Of all school factors that promote the students' successful learning, the professional skills of teachers are the most powerful" (Hunter, 1994, p. 151). She insisted it is not who the teacher is as a person that makes the difference in what students learn. The decisive factor in learning is what the teacher does in the classroom. Are lessons presented in a well-organized and cogent manner?

Hunter's approach to instruction was foreshadowed by Herbart's system. Herbart's Five Formal Steps of the Recitation provides a clear example of a realist paradigm operating in the realm of education. Herbart's ideas, however, would not have achieved the notoriety accorded them today if it had not been for his two German disciples, Rein and Ziller. Effective classroom instruction should follow five basic steps: a) *Preparation*: Review what has already been learned; b) *Presentation*: The new information is explained to the students.; c) *Association*: The new information is related to other information already in the mind; d) *Generalization*: A short rule is formulated explaining the operations involved; and e) *Application*: Students are given sufficient practice so the new information becomes habitual. Herbart's method was very popular in the United States at the end of the 19th century (Lucas, 1972, pp. 395-403).

Hunter's (1984) famous Seven Elements (Steps) of Mastery Teaching, building as it does on Herbart's model, is another example of how mechanistic exemplars can work their way into the language of education. A good instructional unit should have the following Seven Elements:

a. *Anticipatory Set*: A lesson should begin by helping to focus students' attention on the material list.

b. *Objective and Purpose*: The purpose of a lesson should be clearly stated at the beginning of instruction.

c. *Input*: This is when the new information is presented to the students. "The teacher," said Hunter (1984), "must have task-analyzed the final objective to identify knowledge and skills that need to be acquired" (p. 176).

d. *Modeling*: We all learn better when we can see the knowledge or skill applied. Hunter (1984) maintained it is "facilitating for the learners to directly perceive the process or product they are expected to acquire or produce" (p. 176).

e. *Checking for Understanding*: Teachers need to check to see if students understand the information being presented.

f. *Guided Practice*: "New information," Hunter (1984) reminds us, "is like wet cement; it can easily be damaged. A mistake at the beginning of learning can have long-lasting consequences that are hard to eradicate" (p. 71).

g. *Independent Practice*: Students should not be turned loose to practice on their own until the teacher feels sure they know what they are doing.

Toward the end of her career, Hunter (1994) lamented the fact that her lesson design had "unfortunately become a checklist of 'what teachers must do.' This outcome was never intended" (p. 50). However, she continued to advocate its use as an instructional tool. Hunter believed the "deliberate consideration of these seven elements, which can promote effective instruction, constitute the launching pad for planning effective and artistic teaching" (p. 96).

Organism

Jean J. Piaget's (1896-1980) educational theories provide us with a second exemplar. Piaget was a Swiss biologist who became interested in studying the cognitive development of children. Lying at the heart of his theories is an organic metaphor: Life is a process of adapting to an ever-changing environment. Two powerful ideas played a formative role in shaping Piaget's thinking, functional psychology and Rousseau's *Emile.* The influence of functional psychology can be seen in Piaget's belief that children learn by acting upon the world. His indebtedness to Rousseau can be seen in his belief that education must conform to the stages of growth and development children pass through on their way to adulthood.

Piaget (1963), speaking as a biologist, tells us: "Intelligence is an adaptation" (p. 3). Intelligence is an instrument for solving problems and adapting the human organism to its environment. Piaget (1970) viewed intelligence as a creative force in the world. "The essential function of intelligence consists in understanding and in inventing, in other words, in building up structures by structuring reality" (p. 27). The world in which we find ourselves is largely one of our own making. Reality is shaped and changed through human actions. Intelligence and action go hand-in-hand with one another. Piaget (1970) believed "knowledge is derived from action, not in the sense of simple associative responses, but in the much deeper sense of the assimilation of reality into the necessary and general coordination of action" (pp. 28-29).

Piaget was in many ways the 20th century heir of Rousseau's doctrines. What Rousseau suggested intuitively in *Emile*, Piaget confirmed empirically in his investigations of children's cognitive development. It is more than coincidental that Piaget served as one of the Directors of the Jean Jacques Rousseau Institute in Geneva for 54 years. Both thinkers, Rousseau and Piaget, believed education is growth from within. Learning follows an inner timetable of cognitive development that cannot be speeded up through clever instruction. What children need is a non-directive, free-flowing environment in which to find their own way in life.

The centerpiece of Piaget's theory is the idea of equilibration, which has a dual meaning. Equilibration is the adaptive process by which an individual adjusts to his or her environment. It is also the way in which an individual alters the patterns of his or her thinking. Equilibration, in turn, houses two complementary processes — assimilation and accommodation. Assimilation, according to Piaget and Inhelder (1969), occurs when new "data are treated or modified in such a way as to become incorporated into the structure of the subject" (p. 5). Accommodation, on the other hand, takes place when there is a "modification of the internal schemes to fit reality" (p. 5). If learning takes place in a one-sided way, the system becomes out of balance. Too much assimilation can cause a person to become rigid and inflexible. Too much accommodation can result in a lack of stability or continuity. Adaptive learning, Piaget (1970) maintained, gives rise to a productive "balance between continuous assimilation of things to activity proper and the accommodation of these assimilative schemata to things themselves" (p. 158).

The most popularized aspect of Piaget's and Inhelder's (1969) theory is their division of human growth into four stages: sensorimotor (ages birth to 2 years); preoperational (ages 2 to 7 years); concrete operational (ages 7 to 11 years); and formal operational (ages 11 forward). Though some children may enter or exit stages sooner or later than others, they all pass through these same four stages. "Thus the unfolding of the stages may give rise to acceleration or retardation, but their sequence remains constant" (p. 153).

During the first two years of life, the child is in Piaget's sensorimotor stage of development. Behavior during this period is exceedingly reflexive. The infant can suck, grasp, and cry. It is very much locked into its senses. Cognitive activity during the sensorimotor stage is based on immediate sense experience.

The young child, not having language, has no way of categorizing experience. Through grasping, examining, and moving objects, the child is able to formulate an understanding of the world. The exploration of objects forms the cornerstone for all future learning (Sprinthall, Sprinthall, & Oja, 1998, pp. 115-116).

The preoperational stage covers the years from two to seven. During this period the quality of children's thinking undergoes a marked transformation. Children are no longer locked into their immediate sensory experiences. Their ability to store linguistic information increases dramatically. Learning in this period is predominantly intuitive. Children show little interest in logic. They do not worry about logical problems involving reversibility and conservation (Sprinthall et al., 1998, pp. 117-119).

Preoperational children do not grasp the logic underlying reversibility and conservation problems: 10 pennies, when placed in a long line, are seen as being more than 10 pennies when placed in a short line. Children fail to understand that processes can be turned around and run the other way. Subtraction is merely addition in reverse. The ability to solve reversibility problems is not solely a matter of experience. Children must first arrive at the proper stage of mental development before they are equipped to solve reversibility and conservation problems (Sprinthall et al., 1998, pp. 117-119).

The stage of concrete operations represents another major shift in children's thinking. Whereas preoperational children were dreamers enjoying their fantasies, concrete operational children are intent on making everything hard, fast, and real. Children in this period are very literal-minded. They look upon rules as fixed and frozen. They enjoy activities involving counting, sorting, building, and manipulating. Concrete operational children, however, are not able to apply logic to hypothetical problems (Piaget & Inhelder, 1969, p. 98).

Children who are ages 11 or 12 have arrived at the final stage of intellectual development, formal operations. The structures underlying logical thought are now fully developed. Formal operational children can solve abstract, hypothetical problems. Schools can begin teaching algebra and other abstract disciplines. Children in this stage are able to deduce conclusions from general principles. They can use abstract schemata to solve scientific problems. They are also able to formulate hypotheses based on general principles that can be tested in a logical manner. Formal operational schemata enable children to engage in complex problem-solving such as hypothetical-deductive reasoning, scientific-inductive reasoning, and combination reasoning (Piaget & Inhelder, 1969, p. 144).

Though Piaget wrote extensively about the cognitive development of children, he had very little to say directly about education. What he did say closely paralleled the thoughts of Rousseau. Piaget (1970) quoted Rousseau as saying: "'Begin by studying your pupils, for assuredly you do not know them at all'" (p. 140).

Education is to be child-centered, taking children from where they are. Piaget credited Rousseau with the insight that "'each age has its motive force,' that 'the child has its own peculiar ways of seeing, of thinking, and of feeling'" (p. 140). Instruction must be fitted to the different stages of cognitive development. Finally, Piaget approved of Rousseau's "formula of negative education, or the uselessness of any intervention by the teacher" (p. 142).

"I do not intend to teach geometry to Emile," Rousseau (1762/1979) declared, "it is he who will teach it to me; I will seek the relations, and he will find them" (p. 145). Piaget's stand on teaching mathematics reflects a similar point of view. "The development of intellectual operations," Piaget (1977) contended, "proceeds from effective action in the fullest sense" (p. 713). Educators make a grave mistake when they try to teach mathematics at the verbal or abstract level. "Particularly with young pupils, activity with objects is indispensable to the comprehension of arithmetical as well as geometrical relations" (Piaget, 1977, p. 727). The manipulation of objects provides the logical foundation necessary for the solution of mathematical problems.

What is true of learning mathematics is equally true of learning to read. No one has stated the view of readiness better than Rousseau (1762/1979), who said: "At twelve Emile will hardly know what a book is" (p. 116). Reading, prior to the stage of formal operations, does not play an important role in thinking. When children arrive at the stage of formal operations, they have the necessary logical development to use reading as a tool for building cognitive structures. Letter identification is not a necessary step in learning how to identify word meanings. Words do not have any meaning in and of themselves. The reader has to assign meaning to the symbols. Reading comprehension is primarily a matter of the reader anticipating what the words are trying to convey (Wadsworth, 1996, pp. 168-170).

Many educators have noted the importance of play in the growth and development of young children. Rousseau and Piaget were both strong proponents of play. Rousseau's Emile learns virtually everything — science, geography, and music — by engaging in playful activities. Piaget (1970) embraced play with equal enthusiasm: "The child when it plays is developing its perceptions, its intelligence, its impulses toward experiment, its social instincts" (p. 155). Play is a powerful catalyst in the cognitive development of young children, "Whenever anyone can succeed in transforming their first steps in reading, or arithmetic, or spelling into a game, you will see children become passionately absorbed in those occupations" (p. 155). Through play children assimilated reality into themselves: "It is individual thought in its purest form; in its content, it is the unfolding and flowering of the self" (Piaget, 1970, p. 156).

Mind

Jerome S. Bruner (1914-2014) furnished the third exemplar. Bruner was a modern-day Platonist who believed mind was the measure of all things. Bruner's psychology is more than a little reminiscent of Plato's, Berkeley's, and Kant's philosophies. Bruner gained a chance to apply his psychology to the problems of education during the post-Sputnik reforms. In 1959, he was asked by the National Academy of Sciences to chair a summer study group at Woods Hole. The group was composed of scientists, psychologists, and educators. They saw their role as one of launching education into a new era. Bruner was asked to write a report summarizing the findings of the conference. The report was published as *The Process of Education.* The book was quickly acclaimed an educational classic and was translated into 19 foreign languages. The Woods Hole reformers were convinced the trouble with education lay in outdated curricula. "The cure," Bruner (1983) informed us, "was to narrow the gap between knowledge locked up in the university library or the scholar's mind and the fare being taught in schools" (p. 180). One of Bruner's contributions to curriculum reform came in the form of "Man a Course of Study." The project was designed to help fourth, fifth, and sixth grade students explore the meaning of three big questions: (A) What does it mean to be human? (B) How did humans get that way? (C) How can humans become even more human? Bruner (1983) later referred to the project as being "the most moving teaching experience I have ever had" (p. 193).

Knowledge, Bruner (1979) contended, is a model we construct in our heads in order to give meaning and regularity to experience. Reality is never experienced face-to-face. The "real" is always filtered through a mind already programmed with organizing ideas. "We invent concepts such as force in physics, the bond in chemistry, motives in psychology, style in literature as means to the end of comprehension" (Bruner, 1979, p. 120). Mind uses a variety of prosthetic devices as tools for thought. Among these, Bruner (1971) tells us, "are pictorial and diagrammatic conventions as well, theories, myths, modes of reckoning and ordering" (p. 7). Intellectual models are our guiding metaphors, devices for condensing and refining experience. Models permit us to predict and regulate the world around us. "We do the greater part of our work by manipulating our representations or models of reality rather than by acting directly on the world itself" (Bruner, 1971, p. 7).

Bruner (1965) asserted that knowledge has structure. Each academic discipline is composed of a handful of basic ideas that provide the guiding principles around which its body of knowledge is organized. "The basic ideas that lie at the heart of all science and mathematics and the basic themes that give form to life and literature are as simple as they are powerful" (Bruner, 1965, pp. 12-13). Basic ideas permit us to condense factual information into generalized principles. The interesting thing about human perception is not that our senses tell us so much but that they tell us so little. Mind has the capacity for extrapolating a great deal of information from a few scraps of sense data. Humans are not only able to deal with the information at hand, but they are able to go far beyond the evidence given. "The testimony of the senses," Bruner (1983) asserted, "seems less like the primary stuff of knowledge than like fodder for testing hypotheses that precede sense data" (p. 66). Mind possesses its own rational powers for sorting and classifying experiences, thus turning physical stimuli into knowledge.

Bruner discarded the educational doctrine of readiness coming from Rousseau and Piaget. Bruner's (1965) book, *The Process of Education*, replaced it with the proposition that: "Any subject can be taught effectively in some intellectually honest form to any child at any stage of development" (p. 33). Readiness, according to Bruner (1965), is nothing more than a half-truth: "One teaches readiness or provides opportunities for its nurture, one does not simply wait for it" (p. 29). By mastering lower-level skills, children can be prepared to advance to higher-level skills. Readiness for Euclidian geometry can be speeded up by teaching intuitive geometry using blocks and other concrete objects. "The task of teaching a subject to a child at any particular age," Bruner (1973) reminds us, "is one of representing the structure of that subject in terms of the child's way of viewing things" (p. 413). One of the ways to enhance learning is to organize curricula around cycles of instruction, which reviews and enriches students' thinking as they move up the spiral.

The structure of knowledge leads quite naturally to the question of memory. How can memory be improved? Unless information is woven into an organized structure, it is quickly forgotten. Bruner (1965) maintained, "An unconnected set of facts has a pitiably short half-life in memory" (p. 31). Integrating ideas into larger patterns of understanding is the most efficient way of enhancing their retention. When facts are tied to their supporting conceptual structure, they are given a permanence they would not otherwise enjoy. The problem with memory, however, is not one of storage. The human mind seems to have storage space for everything. The real problem is one of retrieval. How can we recover information once it has been placed in storage? The key to recovering information is one of organization. If information has been properly coded, there is a greater likelihood it will be recalled.

Few things can call ideas to mind quicker than a colorful metaphor. Metaphor provides a handy way of coding information. Hunter referred to recent learning as *wet concrete*, which needs to be tended to before it hardens in the wrong way. Piaget borrowed Rousseau's metaphor of *negative education*, letting the children grow up according to nature. Ryle provided us with an equally catchy metaphor, *the ghost in the machine*. The metaphor calls to mind the different opinions surrounding Cartesian dualism. A teacher who subscribes to Piaget's exemplar will have great difficulty accepting Hunter's Seven Steps of Effective Teaching.

The problem of coding leads quite naturally to the problem of transfer. How can what is learned in one setting be called up and used in a different setting? Thorndike restricted transfer to cases involving "identical elements" (as cited in Bigge & Shermis, 1999, pp. 21-31). Knowing Latin, for instance, might prove useful in studying Spanish, but it would be of little help in studying Chinese. If the teacher wishes to have information transfer, he or she will have to teach for it directly. Bruner (1965) took a far more charitable view of the problem of transfer: "Massive general transfer can be achieved by appropriate learning, even to the degree that learning properly under optimum conditions leads one to 'learn how to learn'" (p. 6). By acquiring the structure of a discipline, the individual learns how knowledge is put together. The learner broadens his or her power of understanding. This, in turn, leads to learning how to learn.

Bruner's name has been closely identified with discovery learning. Discovery methodology encourages the person to play an active role in learning how knowledge is generated. Though he stressed the importance of discovery learning, Bruner (1971) did not rely on it to the exclusion of all other methods of instruction. Schools were created to transmit culture. Discovery may not prove to be the most effective way of teaching every lesson. Bruner (1971) stated, "We had better be cautious in talking about the method of discovery, or discovery as the principal vehicle of education" (p. 69). Children learn to share in the culture not so much through discovery as by learning to imitate adult models. Additionally, discovery is not so much a matter of coming to know what exists in the world as it is a matter of coming to know what is inside our own heads. The greatest discovery we have to make lies tucked away inside our own cognitive structures.

The Socratic Method represents one of the best and most effective tools in the teacher's toolbox. Skilled teachers have been using it for the past 2,000 years. The method has its roots in a story told by Plato (380 B.C./1956) in the *Meno*. Socrates calls in a slave boy and, through asking him questions, leads the boy to discover the Pythagorean Theorem. No mean feat. The story illustrates Plato's theory of reminiscence. Learning does not consist of stuffing information into the mind; rather, it is a process of drawing out what is already known. "Seeking and learning are in fact nothing but recalling" (pp. 129-130). Bruner, of course, does not accept Plato's doctrine that the sum total of knowledge is housed in the soul. Bruner (1966), however, does endorse the Socratic Method as a useful tool for opening students' minds: "With Socrates, we know somehow that a dialogue can lead people to discover things of great depth and wisdom" (p. 19). Dialogue between the teacher and the student is instrumental for promoting intellectual growth. "Mental growth is in very considerable measure dependent upon . . . a contingent dialogue by agents of the culture" (Bruner, 1966, p. 21).

CONCLUSION

What does all the theoretical discussion about metaphors and paradigms mean for today's educators? Simply this: If we wish to initiate a revolution in education, we should first formulate a new and powerful paradigm. Creating a new paradigm is no mean task, which is why there have been so few paradigm shifts in either science or education. An Einstein doesn't mystically appear like a genie whenever we uncork a bottle. Truly creative thinking is rarely the byproduct of classroom instruction. So how are we to construct a new, dynamic paradigm for the troubled times that seem to lie before us? "Fundamental progress," Whitehead (1966) reminds us, "has to do with the reinterpretation of basic ideas" (p. 346). Suppose we were to construct a super-paradigm — one that was capable of integrating discordant ideas into a new and powerful synthesis? Aristotle created a grand synthesis of all the knowledge in the Greek world. What is to prevent us from doing the same thing? Such a paradigm would combine qualities from all three of the root metaphors as well as the principal philosophical systems. A grand synthesis of today's knowledge would certainly result in one of Kuhn's paradigm shifts, which is exactly the challenge posed to educator by the model presented in the Figure 1. Metaphor, paradigm, and education — all the cards are on the table. Who will help to construct a theory of everything?

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