The Lasting Contribution of Piaget and Inhelder to a Science of Education

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Crises and solutions in Science, Philosophy and Education at the opening of the 20th Century

> Epistemology is the scientific study of what all other sciences presuppose without examining it: cognition itself. It is thus a philosophical science, fundamental to all other sciences. Only through epistemology can we learn the value and significance of all insight gained through the other sciences.
>
> Rudolf Steiner, preliminary remarks to *Truth & Knowledge*

In founding the science of *genetic epistemology* (Jean Piaget, 1970; Piaget, 1972) Jean Piaget brought a productive ferment into the relationship between 20th century philosophy, science and education. At the opening of the century John Dewey and Rudolf Steiner had each perceived crises in the evolution of thought that would persist through the coming years. In *The Child and the Curriculum* (Dewey, 1902), Dewey anticipated that contradictions inherent in the educational thought of his time would result in irreconcilable conflicts between ideologies and so set persistent obstacles to progress. In *Truth and Knowledge* (Rudolph Steiner, 1892), Steiner demonstrated that ideological assumptions underlying the philosophy, and particularly the epistemology, of his time were prejudicing the understanding of human cognition and consequently the ability to make productive use of the most fundamental instrument of scientific investigation – human thinking. What these crises have to do with a science of education and what Piaget and Inhelder contributed to the bringing of scientific elements into education will be the subject of this paper.

Steiner concerned himself with the grip that Kant and post Kantian philosophy held over the philosophical and scientific investigations of his time. Kant's dictum that the foundations of reality were beyond the capacities of our senses and therefore inaccessible to our experience and reason had, by the end of the 19th century, evolved into a dogmatic assertion that still may be said to underlie much modern popular (as well and scientific and philosophical) world views. Steiner demonstrated that this dictum was built on unnecessary, and indeed unfounded, pre-suppositions concerning 1) an *a priori* world, 2) the nature of experience and 3) the nature of human knowledge. He warned that epistemology would only move forward if it could find starting points that were free of such assumptions. He argued further that the object of knowledge is not to repeat, in conceptual form, something that already exists, but rather to use thinking to create new and more adequate organization of observations.

Dewey focused his attention on the productive resolution of social problems and conflicts. He posited a route to their resolution, a breaking away from pre-formed concepts and positions, and dynamic reconsideration of the conditions underlying problems and conflicts. He presented a method that he referred to as 'reconstruction' which consists of examining situations anew instead of relying on already formed (and consequently comfortable) ideas and solutions. He modeled this type of thinking by taking on educational controversies and demonstrating how to productively reconcile their antinomies. In *The Child and the Curriculum* he took on the conflict between *child centered* and *curriculum centered* approaches to education. He overcame the conflict by presenting the notion that the child's world view was a particular totality, one that is confronted with and ultimately disrupted by another totality, the latter being the abstractions, analyses and classifications that characterize most modern education. But he also saw that the rupturing process could have a reciprocal aspect:

> Abandon the notion of subject-matter as something fixed and ready-made in itself, outside the child's experience; cease thinking of the child's experience as also something hard and fast; see it as something fluent, embryonic, vital; and we realize that the child and the curriculum are simply two limits which define a single process. Just as two points define a straight line, so the present standpoint of the child and the facts and truths of studies define instruction. It is continuous reconstruction, moving from the child's present experience out into that represented by the organized bodies of truth that we call studies. (Dewey, 1902, p.11)

As if responding to these concerns, Piaget, in the succeeding early decades of the 20th century, began to build an empirical science which eventually he referred to as *genetic epistemology*. This new discipline consisted of radical investigation into how children's emerging grasp of the world revealed the workings of the evolution of human thought. These investigations produced, in the end, an empirical challenge to existing conceptions of cognition and of the nature and development of mathematics, philosophy and the scientific disciplines. A biologist by training, Piaget's deepest interest had always been the question of how we come to know. To pursue this interest he engaged in a program of personal development that included undergoing psychoanalysis and employment as a researcher in the laboratories of Alfred Binet who was setting the foundations for modern psychometrics. In Binet's labs Piaget made an observation that had apparently slipped by Binet and his colleagues. Binet construed levels of intelligence as ratios of *mental age* (or the average age at which children are able to solve a particular set of problems) to their *chronological age*. This necessitated a careful study of the success (or failure) of children at each age group in solving specific problems. What Piaget noticed was that children at a particular age not only all failed to solve the same problems but that they gave the same wrong answers! Apparently they were all thinking in the same way, or manifesting a common perspective on the problem and perhaps even of the world. Beginning with this seminal finding he and his colleagues carried on a program of research that continued until the last decades of the 20th century. This program was an empirical investigation of the origins and development of human thought and knowledge inferred from the stages by which children organized their actions on and representations of the natural world.

The Foundations for a Science of Education

In the closing decades of the 20th Century Mauritz Johnson provided the basis for a comprehensive science of education. The most complete summary of his insights and approach appears in his book *Intentionality in Education* (Johnson, 1977). The essence of Johnson's model may be presented succinctly by means of 3 questions that can be productively posed to any educational program. The questions are:

1. What are the goals for learning?
2. How do we know if the goals for learning are being attained?
3. What are the best ways to help learners attain these goals?

What is evident in each of these questions is the central role of '*goals for learning'*. Johnson's model of educational processes is built on the foundation of goals for learning, or as he referred to them -- *intended learning outcomes* (ibid., chapter 2). Johnson proceeded with systematic, almost mathematical, steps to elaborate a model of educational processes using the learning goal, i.e. the intended learning outcome, as the axiomatic unit of educational thinking and research. The answers to the three questions posed above can be seen to generate, respectively, what educators call *curriculum*, *assessment* and *instruction*, the fundamental components of educational programs and processes. The scientific possibilities of this conceptualization appear most clearly in one of Johnson's final papers in which he introduces the *goal contribution unit* as a foundation for educational research (Johnson, 1985). The power of Johnson's insight can be seen in the fact that through the simple act of defining curriculum as 'a structured set of intended learning outcomes' Johnson was able to reconcile the inherent antinomy between child (i.e. learner) and curriculum.

Johnson's model opened the possibility of identifying and reconciling conflicts that were founded on imprecise conceptualizations of educational programs and processes. By doing so he provided a basis for educators to build a body of cumulative knowledge such as those that characterize the crafts and sciences. Johnson's notion of intended learning outcome and the 3 questions provide a meta-language with which one can productively approach virtually any educational problem, issue or proposal. We will use the 3 questions to reveal how Piaget and Inhelder's work provided scientific contributions to the field of education

Piaget and Inhelder's Contribution to Educational Assessment

The relevance of Piaget and Inhelder's contribution to education is most obviously evident as a practical answer to the 2nd of the three questions, the question of educational assessment, i.e. -- **How do we know if the goals for learning are being attained?** A lifetime of research devoted to the development and application of ingenious techniques for eliciting the underlying concepts, skills and motivations of children, from *The Language and Thought of the Child* (Piaget, 1926) to *The Grasp of Consciousness* (Piaget, 1976) has left one of the most comprehensive foundations for a science of

educational assessment. The explication of the clinical interview or *méthode clinique*, in the preface to the *Child's Conception of the World* (Piaget, 1929) set in motion a history of methods for eliciting cognitive and development features of subjects that culminated in works such as K. Anders Ericsson and Herbert Simon's *Protocol Analysis* (Ericsson & Simon, 1996).

In *The Moral Judgment of the Child* (Piaget, 1948), Piaget began to make use of children's participation in activities, specifically their engagement in the game of marbles, to provide an objective correlative for what had previously been simply oral interviews. His growing partnership with Barbel Inhelder accelerated the placement of empirical investigations conducted by children at the heart of these interviews, making them a central feature of their methods. The child's confrontation with phenomena and problems drawn from the history of scientific discovery became the empirical field in which the interviewer studied the properties and processes of cognition. The most extensive example of this use of engagement in empirical investigation as a basis for eliciting cognitive features of children, may well be the 12 investigations that make up the main body of *The Growth of Logical Thinking: from Childhood to Adolescence* (Inhelder, 1958). This work is a model of how the history of science can be employed to learn both about and from the child.

Piaget and Inhelder's Contribution to Instruction

Can it also be said that Piaget and Inhelder have made a contribution to the educational function of *instruction* or teaching, that they have answered the 3rd Question -- **What are the best ways to help learners attain these goals?** We propose that it is precisely Inhelder's contribution, i.e. the placing of empirical investigations of phenomena and problems at the center of the clinical interview, that has enriched the possibilities of what instruction can be and what it can attain. With a phenomenon and a problem at its center, the interview becomes a place of encounter where learner, teacher, the natural world, and the disciplines of human knowledge intersect. The interviewer becomes a guide eliciting concepts from the subject rather than imposing them. This means that the subject's own world may still be found in its direct and personal relationship to Nature. In fact Nature becomes the teacher, letting the subject know directly and immediately whether his conceptualizations are working. The enquiry guide, limiting herself to posing questions and noting how the child's responses may relate to existing disciplines of knowledge, allows the subject to maintain a personal relationship to the phenomena under investigation. When questions or statements posed by the subject indicate readiness for a developmental leap (e.g. a disruption of existing cognitive structures appears to be underway), the guide, can become an active representative of the disciplines of knowledge, and can provide tools or experiences that will support continued enquiry into the phenomenon. Here we see again, this time in the act of instruction, the fruitful resolution of the postulated conflicts between the child and the curriculum. Now the resolution is by means of experiences in which teacher (enquiry guide) and student both become direct investigators and learners in the realms of nature, human cognition and the disciplines of knowledge. If instruction is the actualization of experiences which lead to the attainment of learning goals, then Inhelder's contribution can be seen as a rich source

of such experiences, perhaps one that would be a worthy realization of Dewey's characterization of what is essential to instructional experiences:

> Wholly independent of desire or intent, every experience lives on in further experiences. Hence the central problem of education based upon experience is to select the kind of present experiences that live fruitfully and creatively in subsequent experiences. (Dewey, 1938, pp. 16-17)

Piaget's & Inhelder's Contribution to Curriculum

But what of the first question -- **What are the goals for learning?** Have Piaget and Inhelder made a contribution to c*urriculum* as well? In the third chapter of *Intentionality in Education* Johnson describes how intended learning outcomes are themselves the products of values. We set goals for learning because we value the outcomes. Intended learning outcomes are desired human characteristics. Learning goals represent a vision of the human being that we wish to see become a reality. One can find in *The Growth of Logical Thinking: from Childhood to Adolescence* sets of concepts, skills and dispositions that could form the basis for a curriculum of valued scientific capabilities (Zachos, Hick, Doane, & Sargent, 2000). These include proportional reasoning, hypothetico-deductive reasoning and many other capabilities that have come to be referred to as *formal operational skills*. These capabilities are concisely summarized in chapter 6, "The Role of Invisible Magnetization and the Sixteen Binary Propositional Operations." But why build a curriculum around these capabilities? What would the values underlying such a decision be? What would be the vision of the human being that underlies the development of such qualities? What is it that we define and imagine in the end? Is it an image of the human being as a system or even a collection of logical, mathematical skills? Is the end of education simply the development of specific learning goals which represent socially desired cognitive, affective and behavioral features? Might this not constitute a decomposition of the human being into analytic fragments? Would it contribute to the sense, as Michel Foucault has suggested, that in time "man would be erased, like a face drawn in sand at the edge of the sea" (Foucault, 1970, p. 387). This challenge was taken up most notably at the turn of the 21st century by Alan Badiou, who, while acknowledging that, by default, the human 'subject' can be said to not even exist, then argues that the human subject can be brought into being through devotion to the cause of fidelity to a process of truth (Badiou, 2001). Moreover Badiou argues that pragmatically the individual foundation of such an 'ontology,' can directly be realized in mathematics, that through engagement in mathematics our identity as humanity can itself be activated (Badiou, 2006, 2008). Badiou's argument is presciently anticipated in Piaget's *Structuralism* (J. Piaget, 1970), the latter's comprehensive study of the nature and role of 'structure' in 20th century disciplines of knowledge. In *Structuralism*, Piaget postulates a meta-language for the scientific disciplines of knowledge). He defines *structure* as a *system of transformations complete under closure* and comprised of three key features: the ideas of *wholeness* (in which elements are subordinate to laws), *transformation* (which is the expression of the laws themselves) and *self-regulation* (which operates through the mechanisms of rhythm, regulation and operation) (ibid. p. 16). Piaget presents a grand picture of how common structural features underlie the

direction and products of the contemporary practice of mathematics, physics, biology, psychology, sociology, anthropology and even philosophy. He buttresses this claim by pointing out the iso-morphism of these features with the set of theoretical postulates presented by the Bourbaki group, and then demonstrates the actualization of this iso-morphic feature in children's cognitive representation of the world based on his empirical investigations. The formation of a meta-language for the scientific disciplines permits Piaget to identify and investigate questions that cut across scientific disciplines, for example, the play of biological notions of innateness with Kantian a priorism and Chomsky's deep structure paradigm. Piaget devotes attention to Foucault on several occasions in *Structuralism*, because the latter, in addition to his critique of humanism, has set challenges to structuralism as well. Piaget might have chosen to dismiss Foucault, just as he had already done for other philosophical approaches that he characterized as having unfounded assertions (Piaget, 1971). Instead he chose to give Foucault ample consideration. This is because he sees Foucault's critique as having, "*a real function, that of raising new problems by undermining easy solutions"* (ibid., p. 129). He recognizes that Foucault's work is a productive challenge to structuralism, one that structuralism will have to answer, and in so doing, provide a healthy ferment, even perhaps a disruption, that will allow structuralism to productively reorganize itself and continue to grow. In the end Piaget views structuralism not as an ideology, or even a theory but rather a methodology, a meta-science that will co-exist with and enrich the hypothetico-deductive methods of science.

A Vision of Educational Possibilities at the Opening of the 21st Century

Education is not explicitly addressed in *Structuralism* but the implications of that work are both direct and powerful. The structural features that Piaget identifies not only characterize capabilities to be attained by the learner but describe the course of growth of learning itself. As Dewey suggested, the educational encounter is a meeting of world views (those of the learner, teacher and the disciplines of knowledge) in the presence of the world itself. All three of the players in these encounters (we personify the disciplines here) may be considered to be engaged in a search for truth. An event which disrupts existing knowledge for any of the players opens the possibility for an epistemological shift (recall that Piaget overturned many of our pre-suppositions concerning human cognition on the basis of his study of children's mental development). Such a 'rupture' of existing knowledge provides a pre-condition for Badiou of an 'event of truth', and the possibility for a 'fidelity' to a truth, that characterizes a true human subject. Piaget and Inhelder's work suggests routes for bringing such a humanization into education. The discovery by Kurt Gödel, the master of meta-language, that the rupture of knowledge is a permanent condition, that our logico-mathematical systematizations will always be incomplete, even with regard to their own internal structure (Nagel & Newman, 1958), gives educational encounters the possibility of being a place of caesura where the old and new forms of personal and social knowledge can meet. The argument presented in *Structuralism* provides compelling reasons for organizing a curriculum around intended learning outcomes that accord with a vision of the individual as a wielder of 'logical-mathematical' capabilities, as a discoverer and transformer of knowledge, as a builder of

structures and systems, as an investigator and creator of technology, rather than a passive recipient of past and present cultural forms. Piaget summarizes this colorfully, touching on a resolution of the antinomy of biological innateness vs. a priorism while suggesting a new vision of human development:

> The problem of genesis is not just a question of psychology; its framing and its solution determine the very meaning of the idea of structure. The basic epistemological alternatives are predestination or some sort of constructivism. For the mathematician, it is, of course, tempting to believe in Ideas and to think of negative or imaginary numbers as lying in God's lap from all eternity. But God himself has, since Gödel's theorem, ceased to be motionless. He is the living God, more so than heretofore, because he is unceasingly constructing ever "stronger" systems. (ibid. p. 141)

In the early decades of the 20th century, Maria Montessori (Seldin & Epstein, 2006, pp.8-10), applying the natural scientific eye of the physician, listening carefully to the needs of a community of children put in her care, perceived in their cognitive requirements sufficient commonality to provide the framework for a developmental education program that continues as a flourishing educational paradigm to this day. Steiner himself, in the teens of the last century, at the behest of workers in the Waldorf Astoria cigarette factory in Stuttgart, and based on his own experience tutoring a hydrocephalic child, gave indications for an educational paradigm which is simultaneously a response to the developmental needs of the child and a 'study of man' (R. Steiner, 1996). The implication of their work, and that of Inhelder and Piaget, is that the future of education will increasingly depend on a deeper knowledge of the learner and of the processes of learning as well as on preparation of the teacher in the disciplines of knowledge.

The present paper can only be an initial exploration into a vast field. Also there is a long path to walk yet in building a science of education. Johnson has given us a meta-language and the axiomatic concepts with which to build a science of education. Piaget has given us keys to structural and genetic processes that underlie commonality in contemporary thinking. Together with Inhelder he has given us empirical tools for investigating the development of human knowledge, both ontogenic and phylogenic. But knowledge is not the *be all* and *end all* of education. We are interested not only in what we can know, but what we can express and do. It is not just a question of the need to know but to become human in the fullest sense. The aesthetic and the ethical are at least two other domains that require the kind of disciplined and imaginative investigation that Piaget and Inhelder have given to the processes of human knowledge. Here Dewey and Badiou may have more to offer us as well.

Badiou, A. (2001). *Ethics. An Essay on the Understanding of Evil.* (P. Hallward, Trans.). New York: Verso.

Badiou, A. (2006). *Being and Event* (O. Feltham, Trans.). New York: Continuum.

Badiou, A. (2008). *Number and Numbers* (R. Mackay, Trans.). Malden, MA: Polity Press.

Dewey, J. (1902). *The Child and the Curriculum*. Chicago: The University of Chicago Press.
Dewey, J. (1938). *Experience and Education*. New York: The MacMillan Company.
Ericsson, K. A., & Simon, H. (1996). *Protocol analysis*. Cambridge, MA: MIT Press.
Foucault, M. (1970). *The Order of Things. An Archaeology of the Human Sciences*. New York: Vintage Books.
Inhelder, B., & Piaget, Jean. (1958). *The Growth of Logical Thinking. From Childhood to Adolescence*. New York: Basic Books, Inc.
Johnson, M. (1977). *Intentionality in Education*. Albany, NY: Center for Curriculum Research and Services, State University of New York at Albany.
Johnson, M. (1985). Curriculum's Missing Data Base. *Curriculum Inquiry, 15*(4), 359-360.
Nagel, E., & Newman, J. R. (1958). *Gödel's Proof*: New York University Press.
Piaget, J. (1926). *The language and thought of the child* (M. a. R. Gabain, Trans.). New York: Harcourt, Brace.
Piaget, J. (1929). *The Child's Conception of the World* (J. A. Tomlinson, Trans.). Totowa, New Jersey: Littlefield, Adams & Company.
Piaget, J. (1948). *The Moral Judgement of the Child* (M. Gabain, Trans.). Glencoe, Illinois: The Free Press.
Piaget, J. (1970). *Genetic Epistemology* (E. Duckworth, Trans.). New York: Columbia University Press.
Piaget, J. (1970). *Structuralism* (C. Maschler, Trans.). New York: Basic Books, Inc. Publishers.
Piaget, J. (1971). *Insights and Illusions of Philosophy*. New York: World Pub. Co.
Piaget, J. (1972). *The Principles of Genetic Epistemology* (W. Mays, Trans.). New York: Basic Books, Inc., Publishers.
Piaget, J. (1976). *The Grasp of Consciousness. Action and Concept in the Young Child.* (S. Wedgwood, Trans.). Cambridge, Massachusetts.
Seldin, T., & Epstein, P. (2006). *The Montessori Way. An Education for Life.* Abingdon, Maryland: The Montessori Foundation.
Steiner, R. (1892). *Truth and Knowledge* (R. Stebbing, Trans.). Blauvelt, NY: Steinerbooks.
Steiner, R. (1966). *Study of Man*. London: Rudolph Steiner Press.
Steiner, R. (1996). *The Foundations of Human Experience*. United States of America: Anthroposophic Press.
Zachos, P., Hick, T. L., Doane, W. E. J., & Sargent, C. (2000). Setting Theoretical and Empirical Foundations for Assessing Scientific Inquiry and Discovery in Educational Programs. *The Journal of Research in Science Teaching, 37*(9), 938-962.