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A Pragmatist Contribution to Science, Technology and Innovation (STI) Studies

By

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FOREWORD

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1 INTRODUCTION

The purpose of this essay is to develop a contribution to science, technology and innovation (STI) studies based on John Dewey's instrumentalist version of pragmatism. First, I introduce the field of (STI) studies below (part 1). Second, I present two basic elements of Dewey's philosophy (part 2). Third, I outline the technology conception deriving from the two elements (part 2). Fourth, a mode of inquiry into technological fields is outlined (part 2).

Science, technology and innovation (STI) studies provide, each in their own way, a new window on how society is being structured, shaped and built. These studies give a backstage perspective on society by critically inquiring into the pertinent questions brought up by actual scientific and technological development. If science and technology sometimes seem to open the box of Pandora, STI studies try to open the black boxes of scientific creation, technological invention and wealth creation. In short, STI as a research community can be seen as "organized around the varying and cross-cultural manifestations of the relationship between social context and the processes, cultures and institutions involved with understanding, manipulating, and using nature" (Bowden 1995: 71).

No consensus concerning the specific analytic concepts relevant for understanding the topics of the STI field has emerged yet. Notwithstanding this, "there is recognition that certain disciplines may provide necessary concepts and that any single discipline's concepts alone will not be sufficient. In addition, a variety of methodological principles have been widely accepted" (ibid. 71-72). In the conceptual and empirical inquiries that follow, I draw actively upon the conceptual and methodological plurality that characterizes the STI field.

In the first European guide to science, technology, and innovation (STI) studies (Wouters et al.'s 1998), the activities of around 70 centres for STI studies where mapped, documenting a vast range of research directions within the field. These centres are active in the study of for instance information societal problems; changes in research and innovation systems; relations between STI, politics and democracy; changing relationships between academia, industry and government; science communication; technology assessment; innovation management (at sector, regional and national levels); employment structures and dynamics; globalization and development; new mediums; transport systems; biotechnology; health, food and medicine; environmental problems; energy problems; visual and material cultures; STI and gender issues; and basic theoretical issues.

The themes noted here have emerged over the last 40 years in the discourse of STI, beginning in the 1960s. Following Gary Bowden (1995), social science and humanities research on science and technology prior to the 1960s consisted primarily of historical, philosophical, and to a lesser extent, sociological research which saw science and technology as autonomous entities independent of their social context. He locates the first break with this traditional approach in the mid-1960s, primarily among historians of technology and people interested in engineering education. It was a development in perspectives away from notions of technologies as autonomous and neutral tools towards viewing technologies as complex enterprises taking place in specific contexts shaped by and, in turn shaping, human values.

In this period according to David Edge (1995), several strong disciplinary traditions were developing their own analyses of science and the social contexts of science, they acknowledged science as a social phenomenon. As he sees it, "In the mid-1960s, contingent circumstances encouraged these streams to converge, consciously and explicitly and from their diverse confluences, the 'subject' of STS

emerged" (ibid.: 4). The strong disciplinary traditions noted, was identified by Edge "in a number of well established specialties in history and philosophy (increasingly interacting with emerging themes in the history and philosophy of science, to their mutual benefit), in sociology, in anthropology, and (less strikingly) in economics and the political and legal sciences" (ibid.).

However, the list could be made longer, Edge notes, and maintains that "the range of contexts in which this confluence took place is similarly wide" (ibid.). In ways similar to the objects of study themselves, viz. science and technology, "(l)ocal contingencies set local targets and determined the form of the emerging interdisciplinary dialogue" (ibid.). Nevertheless, even if the STI field has been marked by its inherent diversity since its inception, "the movement has constructed a new picture of science and technology, with some coherence and great imaginative and practical power" (ibid.). Thus, the main conceptual reformation in this phase of the STI field was the contextualization of science and technology.

The second major break from traditional disciplinary views is located by Bowden (1995) in the middle of the 1970s "when developments in the philosophy and history of science opened up the content of scientific knowledge to sociological scrutiny" (ibid.: 71). This new approach argued that the social bases of scientific knowledge should be empirically examined, aiming "to undermine the authority of science by destroying the epistemological privilege that has traditionally justified that authority" (ibid.). In writing about this period, Edge (1995) observes that "the 1970s saw the emergence of a radical, relativistic new 'sociology of scientific knowledge' (SSK)…(drawing)….from work in history, sociology, philosophy, anthropology, cognitive psychology, and linguistics" (ibid.: 7).

The academic humanistic aim of this stand of research was "to develop an empirically informed view of the social nature of scientific knowledge" (ibid.). Edge consider the inception and development of SSK as "one of the main achievements of STS scholarship" (ibid.). An important transformation in the SSK approach in recent years, according to Bowden (1995), "is the growing retreat from extreme social relativism and the recognition that we live in a material world, that is, that the natural world places constraints upon the construction of scientific knowledge and technological artifacts" (ibid.: 71). This is a persistent issue in STI studies discussed below. The main conceptual reformation involved in this development phase of the STI field was to inquire into the ways in which social contexts have effect upon the creation of scientific knowledge. Moreover, it also implied a focus on how science and technology have impacts on society.

Bowden (1995) has identified a third major event that occurred in the late 1980s, viz. the turn to technology within science studies. However, in many ways, he says, "this event is more symbolic than substantive…(because it)…primarily extended the insight of the second development to technology" (ibid.: 71). Through this event, the focus was shifted to technology. This meant that the two communities that had grown out of the two preceding events - and "which had existed in relatively scholarly autonomy" (ibid.) - was brought to communicate much closer which each other.

I would like to point out two of the methodological features that characterize the field today. The first is that the "tension between the descriptive, narrative tradition within history and a more theoretical, explanation oriented emphasis within the social sciences has led to widespread acceptance of explanation at the level of thick description" (ibid.: 72). The other is that "the confrontation between philosophy and SSK resulted in i) an acceptance of relativism as *methodologically* justified and ii) the view that normative statements need empirical, rather that logical grounding (ibid. Emphasis in original.). I will draw upon both of these methodological features in the following inquiries.

The inception of technology studies were characterized by the emergence of the impact and shaping themes: the view on technology as a complex enterprise that takes place in specific contexts shaped by and, in turn shaping, human values and social factors. Students of technology have not been satisfied with the partiality of the impact and shaping themes and have made efforts to go beyond this. These efforts have manifested themselves in a variety of approaches, for instance, evolutionary political economy, complexity theory, technological systems, social construction of technology, actor-network theory and constitutive anti-essentialism.

The aim of employing such approaches and conceptions to the many issues of technology and society should amount to a social, cultural and political critique. In much the same sense as critics of, say, architecture, literature or film find their subject matters in those parts of a society's culture that manifest themselves in a variety of built environments, literary artifacts and cinematic artifacts respectively, critics of technology find their subject matter in those parts of a society's culture that manifest themselves in a variety of sociomaterial artifacts ranging from the simplest tools to the most complex constructions.

Conceptions like technoculture, technoscience and sociotechnology have been coined to indicate the complexity of relations between science, technology, society and culture. They can make us realize that it is not easy to distinguish the technological from the "human". This is because the technological "is within (medical technologies, processed foods), beside (telephones), and outside (satellites)" (Menser and Aronowitz 1996: 9).

> Sometimes we inhabit it (a climate-controlled office space), or it inhabits us (a pacemaker). Sometimes it seems to be an appendage or prosthetic (a pair of eyeglasses); at other times, human beings appear to serve as the appendages (as in an assembly line). Things and their event and states are complicated. Technologies often "relate" to us; at other times we relate to them. The flows are rarely unidirectional; or alternatively (….), perhaps there are many different kinds of technologies, and each "class" effects us in very different ways" (ibid).

It is symptomatic of this substantial role of technology in our society and culture that critique within cultural fields like those mentioned above necessarily also implies a critique of technology of some kind. In this sense, a critique of technology becomes a meta-critique of society and culture. Since all cultures are technological, it becomes a critique of technocultures, their constitution, their manifestation and their interpretation.[1] In this essay, I will contribute to such a critique of technology from the philosophical perspective of pragmatism in which the construction and use of technology is a central component in human social and cultural evolution.

[1] Works with this perspective are found in, for instance, Aronowitz et al. (1996).

2 PRAGMATISM, TECHNOLOGY AND INQUIRY

The field of science, technology and innovation (STI) studies is characterized by openness and pluralism concerning philosophical outlooks, methodological principles and analytical concepts. The purpose of this and the two next parts is to introduce and outline the specific philosophical and methodological perspective upon which my contribution to the field is based. My main source of insight into the perspective known as *pragmatism* is the work of John Dewey (1859-1952). I also briefly refer to a few ideas from the work of Charles Sanders Peirce (1839-1913), with whom Dewey studied logic at Harvard in the first half of the 1880s. It has been written much on these philosophers in recent years. According to James Campbell, the most important factor in the contemporary interest and re-evaluation of Dewey is

> "the growing dissatisfaction with much contemporary philosophizing, with thinking that neither grows out of the problems and issues of our broader society nor is able to offer any assistance to that society as it attempts to address its difficulties" (Campbell 1995: ix).[2]

In this connection, I will emphasize the contributions from and reinterpretations of what can be termed classical pragmatism. One of the main ideas of Dewey underlying this and the next two parts is that the production of physical artifacts (technology in the common sense) and mental artifacts (theories, ideas) are two instances of the same basic process of creative problem solving. More specifically, it is maintained that Dewey's methodology or theory of inquiry grew out of his broader technological conception.

Pragmatism emerged in the United States in the last decades of the 19th century and the first decades of the 20th century and has been characterized as "the only major philosophical system that is uniquely American" (Hill and Traub 1995: 75). This philosophy of pragmatism

> "originated in the United States where it grew out of the historical experience of the American people on their western frontier. Life on the American frontier was a constant struggle for survival, which required many hard choices among alternatives that had to be judged according to their practical consequences. Moreover, the resulting knowledge and understanding of reality had to be used to solve practical problems. In this manner, pragmatism emerged from the historical milieu of the United States to become the folk philosophy of the American people (Kalen 1933)" (ibid.).[3]

As Ryan (1995) argue, Dewey did subscribe to the so-called "myth of the frontier" advanced by his contemporary, the historian Fredrick Jackson Turner. Based on the works of his predecessors Peirce and William James (1842-1910), Dewey and his contemporaries George Herbert Mead (1863-1931), James Hayden Tufts (1862-1942) and other members of the so-called Chicago School developed pragmatism as a philosophical view that included the following;

> "a metaphysics that emphasizes processes and relations; a naturalistic and evolutionary understanding of human existence; an analysis of intellectual activity as problem-oriented and as benefiting from historically developed methods; and an emphasis upon the democratic reconstruction of society through educational and other institutions" (Campbell 1995: 14).

What influenced Dewey in Peirce's perspective was i) his emphasis on the engagement of humans in "cooperative attempts to overcome our intellectual problems" (ibid.: 15) and ii) his belief that a more adequate theory of meaning should be developed in order to "develop more precision in our philosophical formulations" (ibid.: 16). In his own version of pragmatism Dewey combined this

[2] In the case of Dewey, Robert B. Westbrook, in his intellectual biography, comments that the "secondary literature on Dewey is enourmous, though much of it is not worth reading" (1991: 556). Other acknowledged studies of aspects of Dewey's work are Hickman (1990), Campbell (1995), Ryan (1995), Eldridge (1998) and Fott (1998). The most comprehensive intellectual biography of Peirce is Brent (1993).

[3] A more detailed account in the same spirit is provided by Campbell (1995), who argue that the "philosophical work of John Dewey can best be understood - and perhaps ultimately can only be fully understood - when approached through an evolutionary or processive interpretation of the American Experience" (ibid.: 1).

inquiring and critical spirit of Peirce - a generally scientific approach - with James' interest for issues of general and direct human concern; moral, aesthetic, educational and social.

In this part, I will take as a point of departure what Campbell has termed a "naturalistic and evolutionary understanding of human existence" (ibid.). In order to understand both pragmatism in general, and Dewey's conception of technology and social scientific inquiry, I will introduce two basic elements of his work, viz. his view of human nature (section 2.1.) and the role of instrumental valuation (section 2.2.) in his philosophy. These elements are the results of Dewey's inquiry into and interpretation of people struggling intellectually and practically on the frontier of the New World.

2.1 A Pragmatist Conception of Human Nature

Concerning the issue of how pragmatists understand human nature, Joas (1993) argues that

> "American pragmatism is characterized by its understanding of human action as creative action. The understanding of creativity contained in pragmatism is specific in the sense that pragmatism focuses on the fact that creativity is always embedded in a situation, i.e. on the human being's 'situated freedom'" (Joas: 1993: 4).

To see this aspect as a mere adaptation to given circumstances, is to miss the anti-deterministic thrust of pragmatism. In the pragmatist view actors have no choice but confronting the problems they meet in their course of life. However, reality does not prescribe any solution to these problems. Rather, what is called for is creativity on the part of human beings, an accomplishment that brings into the world something objectively new. As Joas takes care to point out, pragmatists acknowledged "the subjective components involved in defining a situation as a problem situation and the subjective constitution of a given worldview" (ibid.). However, this does not mean that the emergence of the problems within reality, as subjective as it is, is the results of arbitrary subjectivism. Rather, a basic idea of pragmatism is the creative solution of problems with a specific emphasis on everyday experience and everyday action. I will elaborate on this point by taking a closer look at Dewey's view on human nature.[4]

When Dewey formulated his theory of human nature, he was influenced by Darwin's evolutionary biology and by Hegel's evolutionary historicism. As John Ryan (1995) says:

> "The one doctrine Dewey preserved intact from intuitionism, from Hegelianism, and throughout his experimentalism was that the mind was essentially *active*, and knowledge a matter of *doing*. The mind was not a passive reflector; we do not confront the world as a sort of recording device picking up 'facts'. Rather, we act upon the world, give it sense, explore its meaning, and working out as we go how best to think about it. The 'world' in Dewey's work was always a generic label for 'what we interact with'" (Ryan 1995: 82).

In line with Darwin and Hegel, Dewey argued that "human beings are biological organisms that harbour certain inborn tendencies that can be modified in a historical process of social evolution" (Jensen 1994: 339). These inborn tendencies were considered as "loose and undirected traits that are so numerous that they cut across one another" (ibid.). Because the relevant human endowments are not always organized and adapted, Dewey termed these tendencies *impulses* rather than instincts.

These loose and undirected traits cannot, he argued, be governors of behaviour. Rather, learned habits govern behaviour. The habits emerge out of impulses, however,

> "in the sense that the former express the latter in ways that are conditioned by the culture in which individuals live. Moreover, Dewey argued that acquired habits are rigid and unbending because

[4] For a more detailed account of Dewey's conception of human nature, see his *Human Nature and Conduct* (1922). See also Campbell (1995: 25-65), Jensen (1988) and Ryan (1995).

> individuals form their personal habits under conditions set by prior customs. Given this rigidity in a setting in which habits and customs are institutionalized, the principal function of institutions is to resist change" (ibid.).

One of Dewey's core concepts, relevant for an understanding of the role of learned or acquired habits for human nature, is that we *learn by doing,* that is, experientially and experimentally. This means that thought and action is essentially intertwined. Dewey views individual motivation and behaviour as diverse, if not dichotomous: it is "combining elements of the rational and irrational, the instrumental and ceremonial, the creative and destructive" (Miller 1995: 52). Things do not tend toward any normal order. Rather, "(r)eality is fashioned by humans, and humans are responsible for its unfolding progress – or retrogress, as the case may be" (ibid.). Thus, the view of reality entertained is that it is continuously evolving. It is, at all times, constituted by "the interaction of individuals acting within the setting of an inherited and continuously evolving social and economic landscape" (ibid.).

This interaction is characterized by reciprocity between individuals and their culture, something which stimulates and demands a certain "sensibility of cultural conditioning" (ibid.). This double character means that

> "(i)ndividuals are seen as creatures every bit as much as creators of the social whole. Each acts on and is acted on by the other; each changes and is changed by the other. Experimentation, trial and error - not formulaic response - is perceived by pragmatists as required for meaningful confrontation of social problems" (ibid.).

This is a central aspect of Dewey's variant of pragmatism - termed *instrumentalism*.[5] Historically this has been regarded as a non-idealist system of social philosophy. One of the arguments of instrumentalism is that knowledge has its origins in human practice or experience and, following this, that "the veracity of knowledge can be determined only by examining the practical consequences of the application of the ideas to concrete problems" (Shuklian 1995: 782). By applying a generally scientific approach inspired by Peirce to generally moral issues inspired by James, Dewey's instrumentalist philosophy "offers a kind of logic of practical activity, and Dewey hopes to use this Instrumentalism as a means to foster social reconstruction" (Campbell 1995: 22).

According to another Dewey scholar, Michael Eldridge, Dewey "thought one should always be aware of the origins of one's thinking in actual experience and the effects of one's thinking on experience. This he recognized in calling his philosophy 'instrumentalism'" (Eldridge 1998: 40). Following Eldridge on this point:

> "The basic notion of Dewey's instrumentalist version of pragmatism is this: Thinking is not something apart from our lives; it is a very effective way to secure our interests. Thinking, despite its occasional pretensions that it is above it all, is really a tool for solving problems, human problems, and philosophy's role is to develop this tool" (Eldridge 1998: 4).[6]

In the same vein, emphasizing the connection to practice, Hill and Traub (1995) define pragmatism as "that philosophy which holds that all reality has practical consequences and that, therefore, certainly the best way and perhaps the only way to know and understand true reality is through the consideration of practical consequences" (ibid.: 75). Just as formulaic response to social problems is rejected by instrumentalists, they also reject purely formal systems of logic that are applicable only to

[5] Dewey had his reasons to coin a new phrase. In the introduction to *Logic: The Theory of Inquiry* he writes: "The word 'Pragmatism' does not, I think, occur in the text. Perhaps the word lends itself to misconception. At all events, so much misunderstanding and relatively futile controversy have gathered about the word that it seemed advisable to avoid its use" (Dewey 1938: iii-iv).

[6] Michael Eldridge consider Larry A. Hickman's *John Dewey's Pragmatic Technology* to be the "best book on Dewey's instrumentalism and thus, in effect, his philosophy as a whole…By considering Dewey's work in the context of discussions on technology, Hickman displays the technical character of Dewey's philosophy" (Eldridge 1998: 203). I will return to Hickman's perspective in the next part.

abstract, non-existential topics of inquiry. Therefore, in order to be meaningful, "knowledge must transcend purely academic discourse and become a practical guide to conscious human action. Ultimately, the usefulness and validity of knowledge is judged by how well it enhances the quality of human existence" (Shuklian 1995: 782).

One implication of the anti-deterministic thrust of the instrumentalist perspective in social philosophy is that the achievement of particular solutions to problematic situations is due to "the conscious, purposeful efforts of human beings to attain it" (ibid.). This means that the instrumentalist perspective cannot be charged of being teleological. The reason is that

> "(t)here are no presuppositions about the existence of immutable, superhuman or suprahistorical forces propelling humanity toward an inevitable destiny. Only human, social action can move society and history in any particular direction. Human beings are the prime movers of social and historical change" (ibid.: 782-783).

Dewey and the pragmatists early on recognized the purposeful and problem-directed nature of processes of knowledge production and the centrality of such processes in the conduct of human life. In order to understand better what is going on in knowledge production, Dewey developed an instrumental logic termed the theory of inquiry (Dewey 1938). Further, he fully and explicitly recognized the possibility of applying this same logic to the question of valuation (Dewey 1939), an issue I turn to next on the way to his conception of technology and social scientific inquiry.

2.2 A Pragmatist Conception of Instrumental Valuation

As William Waller (1989) argues, human beings, in their practice and conduct of life, use a number of valuational processes both individually and collectively. The specific kind of practices focused upon here is the production of physical artifacts (technology in the common sense) and mental artifacts (theories, ideas). In order to arrive at his statement of the instrumental logic of social scientific inquiry, Dewey rejected two basic canons of positivistic thought (Hickerson 1988). The first idea was "that matters of judgement or valuation…(are)…not amenable to the methods of science…(because they)…are wholly personal and therefore unknowable" (ibid.: 178). Dewey's counter argument was that valuations exist in fact and are empirically verifiable (Dewey 1939). The point, as Marc Tool has observed, is that

> "since all social choices require the application of criteria, and since choices produce consequences, one may reflect on the *character* of consequences emerging from the use of a criterion and thus the propriety of the criterion itself. Value judgements are brought within social inquiry" (Tool 1977: 829).

The second idea rejected by Dewey was that of a positive/normative dichotomy and a knowing/doing dualism. This is the foundation of his value theory. His rejection of "the Cartesian knowing/doing dualism logically entails his rejection of the value/knowledge dualism in all of its forms. This makes his theory of valuation a special case of his general theory of knowledge" (Bush 1993: 81).

In fact, as Paul Dale Bush observes, Dewey's "theory of value and valuation is incorporated in his theory of knowledge...(and he)...takes the position that values are a form of knowing" (ibid.). That is, to evaluate something is inextricably intertwined with the knowledge of the matter evaluated and thus the outcome of a process of evaluation contributes to knowledge of the evaluated matter. More importantly, according to Bush, "valuations are essential to the process of inquiry that produces warranted assertions" (ibid.). I return to the question of why Dewey preferred the term *warranted assertion* to the term knowledge. Anyhow, this position - the rejection of a positive/normative dichotomy - was based on Dewey's belief that:

> "(1) to conceive of something as an 'end' is to conceive simultaneously of the 'means' of its achievements and, therefore, (2) it is wholly arbitrary to designate and isolate 'means' from 'ends' in the continuum of phenomena" (Hickerson 1988: 178).

The sources of both means and ends, in Dewey's view, are our actual social experiences. In order to emphasize the continuity of experience as we actually find it, Dewey criticize both tendencies to "posit a neat and inviolate divorce between worldly and experiential means" and a "conception of ends that are the non-experiential stuff of tastes, utilities, or other metaphysical ultimates" (ibid.).

Following Steven Hickerson again, Dewey, in pointing out the place of means and ends in the continuity of experience, realized the need for «an experimental value principle that is consistent with the view of social and economic phenomena as an evolutionary process» (ibid.). Dewey saw criteria for valuation as arising «from within the process itself». This contrasts with the view that such criteria are «externally imposed as some 'self evident' metaphysical ultimate» (ibid.). The important point, already touched upon above, is that when value and valuing are pursued within the social process through the application of intelligence and action to problematic situations, they are regarded as observable phenomena, not as being «transcendant, isolated, or subjective» (ibid). In this way «(e)mergent values, rather, are objectively tested to determine their success or failure in resolving problematic situations» (ibid.). In such objective tests lies also the truth of ideas, because - as Dewey (1938) argued - «a true idea must not only correspond to reality, but also prove to be useful in dealing with reality» (Hill and Traub 1995: 78).

Then, by seeking answers to two questions Dewey extended his view to its ultimate conclusion. First, he asked 'What is the origin of true ideas?' His answer to this question was that "True ideas originate from logical or scientific inquiry, which is open, unbiased, systematic, and creative" (ibid.). Second, he asked 'What is the purpose for which true ideas should be used?' His answer to this question was that "True ideas are intellectual tools or instruments to be used for the purpose of solving important practical problems" (ibid.). Hereby, a core conception from Dewey's philosophy can be made explicit:

> "The instrumental process always begins with the utilization of logical or scientific inquiry to induce true ideas from experience; it always ends with the instrumental application of true ideas to the solution of important practical problems" (ibid.).

This constant movement between spheres - between scientific inquiry and practical application, between meaning and action, between thought and purpose, between ideas and experience, between the abstract and the concrete - is a basic feature in Dewey's philosophy. Here we find a connecting point in discussions between social theorists with pragmatist/ instrumentalist leanings, for instance institutional political economists, on the one hand, and social theorists with Marxist leanings, for instance radical political economists, on the other hand. With these brief points on issues of value, issues that have been shown to permeate the whole of Dewey's philosophical outlook, I now turn to his broad conception of technology.

3 DEWEY'S PRAGMATIC TECHNOLOGY

There is a theory of technology implicit in Dewey's philosophy. I now want to make this more explicit, based on the foregoing part where the basic theoretical elements of his pragmatic conception of technology were presented. In order to do this, I will elaborate further on Dewey's argument that the production of physical artifacts (technology in the common sense) and mental artifacts (theories, ideas) are two instances of the same basic process of creative problem solving. The purpose of scientific inquiry is to produce knowledge artifacts. Therefore, an account of a proper production process must be provided. As a step towards this, I will have the opportunity first to account for a process of producing material artifacts, commonly termed technology or tools. Thereby two parallel and similar processes of creative human effort are accounted for.

It has been argued that Dewey "is, par excellence, the American 'father' of the philosophy of technology" (Ihde 1990: viii). Throughout his long career, he was concerned with technology as a central feature of the development of the society wherein he lived and acted. For Dewey, philosophical inquiry, like any other form of inquiry, takes place as part of, and is directed toward, specific times and places. The problems and opportunities of technology in his age were the concrete point of departure for the development of many of his philosophical insights and he came to see an intimate relation between the problems of technology and the problems of philosophy.

Notwithstanding the time and place specificity of inquiry, his conceptions are still relevant to many contemporary questions involving modern science and technology. An example of this is that Dewey, "long before it became fashionable in history-of-technology circles (…..) described and analyzed the interconnection of science and technology and, simultaneously with Heidegger, argued for a precedence of technology over science, based, in Dewey's case, upon a pragmatic theory of action" (ibid.). I take this to mean that in order to understand science and scientific action in society we should endeavour to acquire an understanding of how technology is produced in that society.

Dewey's pragmatic conception of technology - and his instrumental philosophy in general as Eldridge (1998) argues - has been thoroughly inquired into by Larry Hickman in his book *John Dewey's Pragmatic Technology* (1990). Hickman's investigation is based on the following thesis:

> "inquiry within technological fields - among which he included science as well as the fine and the vernacular arts - formed the basis of and provided the models for Dewey's larger project: his analysis and critique of the meanings of human experience. And it is no overstatement to say that his critique of technology was the warp on which the weft of that larger project was strung" (Hickman 1990: 1).

In this view, technology, its problems and its opportunities, is seen as a thoroughgoing and underlying theme in Dewey's overall work. Several central themes related to Dewey's "inquiry within technological fields" and his basic technology conception is emphasized in Hickman's account. In the following, I will spell out six main issues.

3.1 Theme One

The first theme in Dewey's critique of technology focused upon here has direct relevance for understanding his theory of inquiry, accounted for in the next part of the essay. Hickman argues that Dewey's most insightful treatment of technology is to be found in his "radical reconstruction of traditional theories of knowledge and his replacement of them with a theory of inquiry" (ibid.: 19). Hickman identifies this theme as a specific feature that renders Dewey's critique of technology unique. More specifically, what is unique is

> "his contention that tools and instruments cut across traditional boundary lines such as those between the psychical and the physical, the inner and the outer, and the real and the ideal. This idea, which Dewey cultivated and nourished until it grew into a methodology, was Dewey's instrumentalism" (ibid.: xii).

My understanding of this statement is that *Dewey's methodology or theory of inquiry grew out of his technology conception*.

Dewey constantly pointed out that tools and instruments could not be treated as value-neutral. On the contrary, they must be seen as teeming with values and potentialities that form the basis for intelligent selection of ends-in-view, or things to be done. The notion of ends-in-view means "ends that are alive and active only as they exhibit continuous interplay with the means that are devised and tested in order to secure them" (Hickman 1990: 12). Underlying Hickman's account of Dewey's theory of inquiry, is his thesis that Dewey reconstructed inquiry as a productive skill which artifact is *knowing*, something which means that knowing is regarded as a technological artifact. Hickman's account explicitly introduces and identifies tools and instruments within Dewey's theory of inquiry. Since I find some of his points relevant in this context, I will deal with them in little more detail.

Following Hickman (1990), Dewey treated the role of tools in inquiry in a manner that made it "unproductive and misleading to talk about the 'essences' of tools, suggesting instead that they should be considered in functional terms. A particular object may be a tool in one situation and not in another. Something becomes a tool only when it is used to do some kind of work" (ibid.: 22). This contextual and relative view also concern knowing, Dewey argued: "it is characterizable only relative to the situations in which specific instances of inquiry take place" (ibid.: xii). In this view, knowing becomes an artifact that is "produced in order to effect or maintain control of a region of experience that would otherwise be dominated by chance" (ibid.). However, this does not mean that knowing has reached an ultimate stage even if control has been attained: "when conditions change, further inquiry may be called for if control is still required" (ibid.). In instrumentalism, knowing is always provisional in the sense that it can - and should - always be revised and reconstructed when needed.

This aspect of Dewey's account of technology - active productive inquiry - is emphasized by Hickman as a very important one. Just as particular objects *may* be tools in particular situations, active productive inquiry "is relative to an individual in a concrete situation. It is impossible to say absolutely of a particular situation….that it does or does not require inquiry. Seen only from the standpoint of an accomplished goal, a task has been brought to completion (ibid.: 23). Since Plato, most of the philosophic tradition has taken the goal of inquiry to be epistemic certainty. This is not the case in Dewey's view, a corollary of which is that inquiry is "a matter of ongoing interaction with novel situations by means of constantly refashioned artifactual tools (ibid.: xii).

Dewey did go much further than most philosophers of technology in arguing that "technological instruments include immaterial objects such as ideas, theories, numbers, and the objects of logic (such as logical connectives)" (ibid.: xii-xiii). The point is that, seen from the position of his "technologized theory of inquiry they are all the same: they are instruments that may be used to resolve problematic situations" (ibid.: 25). Because neither the realist position nor the idealist position "was capable of developing an adequate understanding of the function played in knowing by tools and media of all sorts" (ibid.: xiii) they were both rejected on the grounds of Dewey's instrumentalist account of inquiry.

In Dewey's technologized theory of inquiry, a distinction between extra-organic and inter-organic tools is not appropriate. Insofar as controlled thinking uses tools and instruments it is technological: "some of those tools are conceptual; some, physical; some, the hardware that extends our limbs and

senses" (ibid.: 36). Within Dewey's theory of inquiry, there is great flexibility in that tools of all types can be utilized. Distinctions between various kinds "are made chiefly in terms of the various materials on which they operate and to which they are appropriate, and of the degree of precision required for the task at hand" (ibid.). Eventually, how does Dewey define technology? He does not provide any single definition of the term but rather uses it to characterize a wide range of activities.[7]

However, as Hickman points out, "in at least one important sense technology can be said to be the appropriate transformation of a problematic situation, undertaken by means of the instrumentalities of inquiry, whatever forms those instrumentalities may take" (ibid.: 44-45). As a summing up of this theme, viz. Dewey's tool-using or instrumentalist account of inquiry, Hickman is on the mark:

> "It is no overstatement to say that for Dewey properly controlled inquiry exhibits the most general traits of all other types of productive skills and that its artifact, knowing, exhibits the most general traits of all other successful artifacts" (ibid.: 19).

In the next part of the essay, I will account in more detail for the productive skill that Dewey termed *properly controlled inquiry*.

3.2 Theme Two

A second theme in Dewey's critique of technology that I want to focus upon here is closely connected to the understanding of inquiry as an active productive skill whose artifact is knowing. This theme is Dewey's more general concern with how *all sorts of* artifacts, tools, media and instruments come to be, how they change human experience and what they portend. However, an even more fundamental issue was that Dewey sought to demonstrate that *the methods and means by which technological inquiry takes place are the methods and means by which all knowing is generated*. Concerning this important feature of Dewey's "inquiry within technological fields", Hickman points out that it was

> "his contention that what lies beyond theory and practice, and what allows them to have commerce with one another, is the production of testable artifacts, among which he includes both those things popularly called 'mental' and those popularly called 'physical'. Dewey's critique of technology is above all a critique of the production of novel and testable artifacts" (ibid.: xi).

Dewey turned on its head the classical Aristotelian view that the theoretical sciences are superior to those that are practical and productive and that the practical sciences are superior to those that are productive.

Having done this, Dewey could describe science as "a type of productive technology" (ibid.: xiv). Even in its most abstract form, this kind of activity involves constructed artifacts. These are tried and tested, first theoretically within a realm of abstract possibilities and then empirically with respect to existential problematic situations. To Dewey, theoretical exercises within the abstract realm "become special tools of activities that are practical" (ibid.: 15) and, as Hickman argues, because "practice that is intelligent (….) involves the constant production of new artifacts, including 'internal' artifacts such as refined habits, production takes precedence over and becomes a guide to practicality" (ibid.). Thus, *pro-duction*, a leading to, and *con-struction*, a drawing together, become the central concepts in instrumentalism. These metaphors, Hickman argue,

[7] As Larry Hickman points out: "Dewey variously writes of technology as the active use of productive skills; as the most satisfactory method of inquiry; as production within the fine, vernacular, and industrial arts; as what distinguished the scientific revolution of the century of Galileo from the science prior to it; as the general use of tools (including language, which he calls the tool of tools); as industry and commerce; as an essential ingredient in education; and as planning in the various forms in which it corresponds to specific human social and political arrangements" Hickman (1990: 58). However, as Hickman also points out, this list is far from exhaustive. An addition to this list is Michael Eldridge's (1998) discussion of Dewey's "political technology" which should be interpreted as the political means to achieve social reconstruction or social change.

> "reflect Dewey's preoccupation with inference that is warrantable within a community of inquiry. Production and construction, terms that are utilized extensively within technological fields, were carefully chosen and extensively utilized by Dewey to articulate his instrumentalist position. Dewey consistently argued that human beings build their world by building the meaning of their world. His metaphors, from the early essays in the 1890s to those published almost sixty years later, were technological ones" (ibid.: 111).

To use Dewey's metaphors, the "pro-duction, a leading toward, and (the) con-struction, a drawing together, of various parts and pieces in order to make" (ibid.: 18) novel and testable artifacts is one of the main themes within science, technology and innovation studies. From a variety of perspectives STI scholars inquire into aspects of the processes through which artifacts are produced, constructed, constituted, built, represented, given meaning, etc. Such inquiry is directed towards a range of different artifacts, both material and immaterial. In very simple terms, the production and construction of material artifacts have been the main focus of technology and innovation studies while the production and construction of immaterial artifacts, in the sense of scientific knowledge, has been the main focus of science studies.

3.3 Theme Three

A third theme in Dewey's critique of technology relates to a point made above. Dewey found it unproductive and misleading to talk about the essences of tools and said that they instead should be considered in functional terms. This is an important point that can be elaborated a little further. As Hickman points out, in Dewey's view

> "technology has no "core", since experience itself, of which technological activities and products are part, is accessible only by shifts of interest and focus. Technology is instead the sum of concrete activities and products of men and women who engage in inquiry in its manifold forms: in the sciences, in the fine and useful arts, in business, in engineering, and in the arts we call political" (ibid.: 202).

To think of objects as comprising fixed essences indicated to Dewey "an exaggerated sense of the importance of investigations already carried out" (ibid.: 52). Technological artifacts are not essential; they are neither found nor discovered as something existing before their construction.

Contrary to an essentialist view, Dewey contended that technological artifacts are constructed through the use of productive skills and that "the construction of theories is a special case of the use of productive skill, that is, a special type of technical production" (ibid.: 18). What is at centre stage for Dewey, then, is active productive skill "because it includes and informs both the theoretical and the practical whenever and wherever they are effective" (ibid.). Therefore, rather than being fixed, completed essences, unalterable for all times, technology was for Dewey "an active method of generating and testing new skills, as well as reconstructing old ones" (ibid.: 19). The question of essentialism, that is, whether technologies have essences, is a longstanding issue in the field of technology studies. The notion that *theory construction is a special case of using productive skills* will inform the account of pragmatist scientific practice that I give in the next part of this essay.

3.4 Theme Four

A fourth theme in Dewey's critique of technology that I would like to mention briefly is his treatment of the issue of technological determinism. This concerns the question to what extent technological objects, events, methods, organizations, systems and laws determine human actions, including their modes of relating to one another. In short, Dewey rejected all forms of determinism, including technological varieties. Just as he did not accept the existence of fixed, completed essences he did not accept the existence of inevitable historical forces that worked beyond human will. Rather, he "argued that technological conditions form the necessary but not the sufficient conditions for technological

progress" (ibid.: xiv). To Dewey, this meant that ultimately, the "responsibility for the future lies in concrete decisions made by human beings, both singly and in groups" (ibid.).

3.5 Theme Five

The fifth theme can be introduced by pointing out that Dewey's philosophy was one of the main building blocks in the work of his student Clarence Ayres. Ayres was one of the founders of American institutional economics and in his theoretical work several aspects of Dewey's technology conception can be identified. As pointed out, this conception grew within the version of pragmatism that Dewey termed instrumentalism that was his lifelong critique of tools and media of all sort (Hickman 1990). For instance, Ayres found Dewey's instrumental value theory especially relevant when developing his institutional theory of technology (Tool 1994a, DiGregori and Shepherd 1994).

Theorizing on technology in the instrumentalist tradition has always stressed that it is a continuing problem solving process and according to Hickman (1990), Dewey understood the term instrumentalism itself as a cognate of technology. Both Dewey and Ayres emphasized that *tools or technologies, in the same way as ideas or knowledge, are instrumental in processes of human problem solving*. Following this, the success of an idea or its embodiment in technology is the degree to which it solves a problem. They repeatedly emphasized that "the truth and its working out are two aspects of the same process" (DiGregori and Shepherd 1994: 320). Thus, in Dewey and Ayres's view, technology is primarily ideas.

One point touched upon above is that the continuing problem solving process is neither teleological nor utopian. Rather than focusing narrowly on one "ultimate" end, problem solving rather treats several possible ends-in-view. Dewey acknowledged that *technology understood in this sense is both a problem solving and a problem creating process.* He was always attentive to the negative aspects of technology. However, he saw human problems, not as a source of despair, but as an opportunity to create. As DiGregori and Shepherd (1994) point out:

> "The opening thesis of Dewey's *The Quest for Certainty* (1929) concerns the difference between responding to adversity by seeking to propitiate supernatural powers through a sheltering belief system or by fashioning the means to overcome adversity and in so doing generate the ideas and technology that enables us to create the arts and civilization. All the vital areas of human endeavour are transformed by technological change and the creative potential it engenders" (DiGregori and Shepherd 1994: 321).

3.6 Theme Six

The sixth theme was touched upon above when pointing out that all problem solving involves the value-laden activity of problem definition. If we do not have a theory of value, however, we can not distinguish tools and technology from trivial gadgets and contraptions. If we *have* a theory of value, on the other hand, we can speak about, for instance, technological progress and, as was one of the main concerns of Ayres, use the concept to lay the foundation for a theory of economic development. Ayres attempted to construct, along instrumentalist lines, a theory of political economy appropriate to technologically based democracies.

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In this part, I have outlined several aspects of a Deweyan or pragmatic technology conception. Bearing in mind the view that Dewey's methodology or theory of inquiry grew out of his technology conception, these aspects can and should also inform the understanding of that part of his philosophical work.

- First, technology and tools cut across the distinction between the material and the immaterial, that is, there is no firm distinction between the physical, on the one hand, and the psychical or social, on the other hand.
- Second, the focus of a critique of technology is above all on the processes through which novel and testable artifacts are produced, constructed, constituted, built, etc.
- Third, technological artifacts are not essential. They are neither found nor discovered as something existing prior to their construction and the features that should be inquired into - their construction, their constitution, their meaning, their function, etc. - should not be presupposed.
- Fourth, in Dewey's perspective all forms of determinism, including technological varieties, are rejected.
- Fifth, concerning the sphere of practicality, both knowledge and technology are instrumental in non-teleological and non-utopian processes of human problem solving. At the same time, however, knowledge and technology is also a problem creating process.
- Sixth, a theory of value is necessary in order to distinguish between tools and technology, on the one hand, and trivial gadgets and contraptions, on the other hand. In this way, the issue arises how questions of values and evaluation are accounted for in inquiries into technological production and practice.

In this part, tools to inquire into conceptual subject matter have been established. In the next part, I account for Dewey's conception of social scientific inquiry and the close connection between this and his broad, pragmatic conception of technology. This means that the conceptual tools presented is situated into a mode of producing knowledge artifacts.

4 A PRAGMATIST CONCEPTION OF SOCIAL SCIENTIFIC INQUIRY

From the beginning of pragmatism, its model of inquiry was a group of inquirers trying to produce good ideas and trying to test them to see which ones have value in dealing with reality. In this perspective inquiry is cooperative human interaction with an environment. Both aspects are vital; i) the active intervention in and manipulation of the environment; and ii) the cooperation with other human beings. I take this point of departure because pragmatist social scientific inquiry must be seen both as derived from a broader view of the role of inquiry in society and as a special instance of human action in general. In this part, I will focus on some guiding principles relevant when seeing the practice of social scientific inquiry from the perspective of pragmatism. I will draw mainly on Dewey's work because it was here that classical pragmatism was brought closest to social theory and social science for the first time. His work has since been one of the main sources of insights into these matters.

Important aspects of Dewey's conception of inquiry will be outlined in more detail in the following. To start the exposition, however, what was Dewey's definition of inquiry? He defined it as follows:

> «Inquiry is the controlled or directed transformation of an indeterminate situation into one that is as determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole» (Dewey 1938: 104-105. Emphasis removed). [8]

The different concepts and ideas contained in this definition will be discussed following Dewey's distinction between three phases of the process of inquiry (Dewey 1903 in Field 1996), a distinction he maintained but modified and developed throughout his career.[9] In the first phase, problematic situations are identified and formulated (section 4.1.). In the second phase, the focus is on subject matter pertaining to the problematic situations (section 4.2.). The third phase involves construction of hypothetical (theoretical and practical) solutions to the problems formulated (section 4.3.). I close this part by outlining some of the implications for practical inquiry of the three phases (section 4.4.).

4.1 Phase 1: Identification and Formulation of Problematic Situations

Since the activity of inquiry is so closely connected to dealing with reality, I start this section with some ontological considerations from a pragmatic point of view. As has been frequently observed across our various specialized social contexts, we share in a fundamental commonality viz. that we each will have had, at some point, the experience of an "obdurate reality." We note a resistance, as the efforts made to execute our wills are at times restricted, often in what comes to be rather predictable ways. It is from this observation that the ontological realism associated with the pragmatism of Dewey and Pierce springs.

[8] According to Ryan (1995), Dewey struggled for sixty-odd years to develop "a logic of the processes by which knowledge is reached….His last published attempt to produce such a logic appeared when he was eighty. The book that embodies it, *Logic: The Theory of Inquiry* is very long, very dense, and very difficult. It was unappreciated in Dewey's lifetime, and unlike his ethics, his politics, and his metaphysics, it has not gained new admirers in the last decade and a half. Even so, the project was not a complete failure" (Ryan 1995: 72).

[9] Since this early formulation, Dewey's conception of inquiry has been outlined in several ways, both by himself and by his interpreters. David Fott, for instance, emphasize the variant from *Democracy and Education* (1916: 157): "Dewey's notion of scientific method is that of a reflective process consisting of several steps: (a) 'perplexity'; (b) 'a conjectural anticipation'; (c) 'a careful survey' of all considerations; (d) 'elaboration of the tentative hypothesis to make it more precise and more consistent'; (e) acting on the hypothesis in order to test it (*DE*, 157). These steps are guidelines, not rigid rules to be followed in every scientific inquiry. The exact method of one inquirer will vary from that of another 'as his original instinctive capacities vary, as his past experiences and his preferences vary' (*DE*, 180)" (Fott 1998: 43).

It is in exploring those patterns of resistance, in the developing of hypotheses about them, and in testing and evaluating those thoughts, that we develop severally and communally, a complex and highly elaborated understanding, a sense of an independent reality. That resistant reality is what sets the parameters of our non-social problem situations and sets several of the constraining parameters of our social problem situations. In so doing, that resistant reality provides the occasion and the motivation for the efforts we make to apprehend the real significance of things and thus to acquire knowledge.

First, the realism of Dewey's philosophy should be pointed out. Much misconceived critique of Dewey for being an anti-realist has been put forward. However, as Tiles (1988) points out, «Dewey insisted on the right of his own version of pragmatism to be regarded as a 'realism' (ibid.: 142). Bush argues that «Dewey believed in a reality that is independent of inquiry» (Bush 1993: 72). The basic point here is that the indeterminate situations that motivate subsequent inquiry arises out of existential circumstances that exists before the process of inquiry start. It is these existential circumstances that are transformed as a result of inquiry, not the state of mind of any involved actors.

The ontological hypothesis incorporated in Dewey's philosophy is manifest in his *Logic: The Theory of Inquiry* (1938).[10] To illustrate his position on matters of ontology, Bush interprets it to entail among other things, the following views:

> «(i) society, as a system of institutions, is real and not merely a figment of the intellectual imagination... (ii) continuity in human experience is not only a convenient theoretical construct but is a real process, the disruption of which has consequences independent of our ability to conceptualize them in deterministic mathematical models... (iii) social and individual value formation are real processes and, as such, must be subject to investigation rather than postulation... (iv) the process of institutional change is not merely a matter of shifting ideologies, or changes in linguistic conventions, but changes in real habits of behaviour that have real consequences which may or may not be captured in discourse... (v) physical and cultural processes are part of a contingent universe that guarantees nothing, thereby imposing the necessity of choice on the human agent.... (vi) human choices have real consequences for the physical and cultural processes of which they are a part» (Bush 1993: 73).

The realism in question here is an entirely ontological doctrine that material objects exist externally to us and independently of our sense experience. The locus classicus for this position termed *pragmatic realism* is Charles Sanders Peirce. This realist position enters early and explicitly into Peirce's work and is retained throughout. In 1905, in summarizing the basics that constitute his position, Peirce writes:

> «Another doctrine which is involved in Pragmaticism as an essential consequence of it...is the scholastic doctrine of realism. This is usually defined as the opinion that there are real objects that are general...[including]...the modes of determination of existent singulars» (Peirce 1934: 5.453.).

In short, to use Peirce's terminology, there are *existent singulars* or *Firsts*; there are real relations between and among them, termed *Seconds*; and there are real general laws of relation termed *Thirds*. Moreover, Peirce is explicit as to the mind-independence of the real: "That is real which has such and such characters, whether anybody thinks it to have those characters or not. At any rate, that is the sense in which the pragmaticist uses the word" (Peirce 1990: 132).

When we encounter the obdurate reality, we are motivated to acquire knowledge based on our beliefs about that reality. The method of establishing beliefs that serves us best in the project of locating stable, long-lasting (or gradually evolving) beliefs, and the only one endorsed by Pierce, is of course

[10] James Campbell (1995: 68) writes that the "central source for Dewey's understanding of metaphysical inquiry is his monumental, although tremendously difficult, *Experience and Nature* of 1925 (revised edition, 1929)".

the method of science. This is "a method...by which our beliefs may be determined by nothing human, but by some external permanency - by something on which our thinking has no effect" (Buchler 1940: 18) and it is just this determination of belief by that which is objective that gives the method its merit.

The *permanency* of which Peirce speaks is *external* in the sense that it is not in any way affected by the thoughts that any person might have about it. Further, it is not limited in its effects to any one individual. The *permanency* in question affects all persons equally, although each individual is affected according to his or her particular sets of relationships to that external permanency. In other words, although it can appear differently to each one of us, we all experience the appearance of one thing - the Real.

Though being realists, pragmatists do not believe that the formulation of eternal verities, first principles or essences is of any assistance in the pursuit of inquiry. Pragmatism is non-foundationalist. As an alternative to foundationalism, pragmatism is a contextualist approach in which knowledge is not deduced from first principles, but is developed out of a consideration of the context of which a purported fact or idea is considered to be a coherent part. For Dewey the relevant context was *the problematic situation*, which arises out of the effort to apply inquiry to what he called an *indeterminate situation*. These situations arise, as pointed out above, out of encounters with resistant reality and are experienced as different patterns of resistance varying according to the details of the situation.

Following Field, the first phase of the process of inquiry begins with the problematic situation. According to Field, this is

> "a situation where instinctive or habitual responses of the human organism to the environment are inadequate for the continuation of ongoing activity in pursuit of the fulfilment of needs and desires. Dewey stressed in Studies and subsequent writings that the uncertainty of the problematic situation is not inherently cognitive, but practical and existential. Cognitive elements enter into the process as a response to precognitive maladjustment" (Field 1996: 4).[11]

In this connection, Bush (1993: 63) terms an «indeterminate situation....a precognitive state of affairs in which individuals has a sensed awareness that something is wrong.» An indeterminate situation, which «is not itself a mental condition» is *the source of doubt*, «which is the starting point of inquiry» (ibid.). In Dewey's own words an

> "indeterminate situation comes into existence from existential causes, just as does, say, the organic imbalance of hunger. There is nothing intellectual or cognitive in the existence of such (indeterminate) situations, although they are the necessary condition of cognitive operations of inquiry. In themselves they are precognitive" (Dewey 1938: 107).

Following Bush (1993: 64) again, a «problematic situation is a cognitive construction which comes into focus as inquiry is brought to bear on an indeterminate situation.» Rather than define themselves precognitively, then, problems are conceptualized through the utilization of all the theoretical and observational tools of coordinated inquiry (Bush 1993).

Problematic situations, in short, necessitate choice, and choice requires criteria for valuation, which arise from within the process of inquiry itself. According to Tool, such instrumental valuing

> «encompasses the knowledge-guided use of conceptual tools and analytical skills as means to transform an indeterminate situation - don't know, don't understand, can't explain, can't act - into a more ordered and determinate end-in-view where consequences are observed, unknowns become

[11] The reference is to *Studies in Logical Theory* published in 1903. More details on this work are provided in Rockefeller (1991) and Westbrook (1991. Especially page 71-77).

knowns, and greater congruency between expectations and outcomes is achieved» (Tool 1994c: 407-408).

This method for selecting criteria depends upon intellect, creativity and cognitive perception of the whole system of relations among the elements of the situation and the possible outcomes of various different courses of action. This means that in Dewey's theory of knowledge, the practical activity of the inquirer is regarded as critical to the process of inquiry and the creation of knowledge. As Dewey says in *The Quest for Certainty* (1929) - his critique of foundationalist metaphysics: "(I)f we see that knowing is not the act of an outside spectator but of a participator inside the natural and social scene, then the true object resides in the consequences of directed action" (Dewey 1929: 157).

Another point I would like to make is that the resistant reality that is experienced by actors is constituted by a continuity of the types of situations discussed here. In the process of inquiry, we are dealing with a consecutive history of situations experienced as indeterminate - problematic - determinate - indeterminate - problematic - determinate, etc., etc. In addition to situations following one another in time, actors will of course also experience several situations in parallel at the same point in time. In any case, all current and past situations are the result of historical processes and cumulative change and we need to understand this character of the settings to be investigated. In order to achieve this, the inquirer has to use theoretical tools to reconstruct particular sequences of situations that are thought to contribute to the end-in-view of inquiry.

Following Dewey, an "indeterminate situation becomes problematic in the very process of being subjected to inquiry" (Dewey 1938: 107). This means that "(t)o find out *what* the problem and problems are which a problematic situation presents to be inquired into, is to be well along in inquiry" (ibid.). When we have a problem, we do not have to grope blindly in the dark, he says. The institution of a problem has practical import for the process of inquiry:

> "The way in which the problem is conceived decides what specific suggestions are entertained and which are dismissed; what data are selected and which rejected; it is the criterion for relevancy and irrelevancy of hypotheses and conceptual structures" (ibid.).

I deal with such matters as specific substantial suggestions, data selection and criteria for relevancy throughout the rest of this part.

I now return to a point established above, viz. the important role of valuations in Dewey's conception of the process of inquiry that produces warranted assertions. Bush (1993), in a rough approximation, has pointed out the logic Dewey uses to reach this position: «the rejection of the knowing-doing dualism places 'doing' within the process of inquiry. This means that practical judgments of 'what should be done' are essential to the process of inquiry» (ibid.: 82). To Dewey, then, "(t)here is no inquiry that does not involve judgments of practice" (Dewey 1938: 174). At every critical point in the process of inquiry, the inquirer does judgments of practice. Therefore, Dewey says:

> "The scientific worker has continually to appraise the information he gathers from his own observations and from the findings of others; he has to appraise its bearing upon what problems to undertake and what activities of observation, experimentation and calculation to carry out. While he "knows," in the sense of understanding, systems of conceptual materials, including laws, he has to estimate their relevancy and force as conditions of the particular inquiry undertaken" (ibid.).

From this statement, Bush has made some points that are important for a pragmatist conception of inquiry.

First, the behaviour of inquirers are directed by judgments of practice «both in the formulation of hypotheses and in the testing of their consequences» (Bush 1993: 82). Second, without such judgments of practice by inquirers «the warranted assertions that are the outcome of competent inquiry cannot be

formulated» (ibid.). By arguing that judgments of value are a form of practical judgments, Dewey is incorporating valuations into the pragmatist conception of inquiry. Having done this, he points out that his "theme is that a judgment of value is simply a case of practical judgment, a judgment about the doing of something" (Dewey 1915: 29). Hereby, the place of valuations and value judgments has been incorporated into the *practice* of doing inquiry. Now, this is carried a step further as the activity of evaluation is seen as an integrated part of the activity of appraising empirical subject matter pertaining to the problematic situations instituted.

4.2 Phase 2: Focus on Subject Matter Pertaining to Problematic Situations

In seeking causal comprehension of that which produces indeterminate situations, inquiry is purposive. In order to provide for the disclosure of the character of, and problems within, the experienced continuity of situations inquiry must focus on data or subject matter (Tool 1994b). According to Field, "the second phase of the process involves the isolation of the data or subject matter which defines the parameters within which the reconstruction of the initiating situation must be addressed" (Field 1996: 4). Throughout his writings, Dewey's position is that the facts do not speak for themselves. To get started, he argued, "inquiry requires empirical evidence; but to qualify as evidence, factual propositions must be functional within the scope of the theory developed to guide the solution of the problem under consideration" (Bush 1993: 66-67). The function of factual propositions "is to serve as evidence and their evidential quality is judged on the basis of their capacity to form an ordered whole in response to operations prescribed by the ideas they occasion and support" (Dewey 1938: 113).

A recurring theme in Dewey's writings on inquiry (Dewey 1938) is his discussion of the *conjugate relation* or *conjugate correspondence* that must hold between the empirical and theoretical dimensions of inquiry. He expresses this relation as follows: "Observation of facts and suggested meanings or ideas arises and develops in correspondence with each other" (ibid.: 109). In the following, as Bush (1993) acknowledge, Dewey expands on this idea:

> "Inquiry demands....operations of both observation and ideation. There would be no control of the process of inquiry if each of these operations where not expressly formed with reference to the other....in controlled inquiry, the entire object (of theoretical formulations) is to attain *that* meaning or conceptual structure which is best adapted to instigate and direct just those operations of observation that will secure as their consequences just those existential facts that are needed to solve the problem at hand" (Dewey 1938: 133. Italics in the original).

This relation between ideas and facts or theory and empirical matter implies the following notion: "factual propositions are theory-laden since a theoretical formulation is required to transform data into evidence" (Bush 1993: 67). Another important point drawn from this perspective is "that theoretical formulations that fail to contribute to the end-in-view of providing a unified whole, including empirical observations that lead to that end, must be abandoned in favour of alternative hypotheses that do" (ibid.). This provides a prime motivation for conducting theoretical discussions in the sense of alternative solutions to the problem at hand. However, to get the inquiry further towards solutions, empirical subject matter must be appraised. In order to accomplish this, a methodological tool is needed to construct evidence from data.

Dewey argues that valuations are critical to the determination of what the relevant facts are. The theoretical frame of reference in which facts are converted into evidence is a normative frame of reference. This point has particular relevance for the determination of the facts in any given inquiry. The relevant practical issue to focus upon in this phase is the mode of data collection pursued, data that will be the subject matter of subsequent evidence construction. Following Wiebe Bijker (1987: 191) "part of the task of the emerging new field of technology studies is the identification of research sites at which the complexity of the seamless web is manageable but which at the same time serve to capture key aspects of technological development". Such locations are termed *"strategic research*

sites" (ibid.). In terms of the present mode of inquiry, strategic research sites can be seen as the locations at which the relevant subject matter of problematic situations can be identified and collected. When one as a STI worker arrives at such a site with the purpose of conducting some sort of inquiry, several well-developed tools and strategies for social scientific inquiry are at our disposal; experiment, survey, interview, archival analysis, history and case study.

According to Platt (1992: 46), the case study strategy begins with "a logic of design....a strategy to be preferred when circumstances and research problems are appropriate rather than ideological commitment to be followed whatever the circumstances" (cited in Yin 1994: 12). Yin's technical definition of this logic of design begins with the scope of a case study: "A case study is an empirical inquiry that i) investigate a contemporary phenomenon within its real-life context, especially when ii) the boundaries between phenomenon and context are not clearly evident" (ibid.). The deliberate ambition to cover *contextual conditions* is thus a motivation for using the case study method.

Because of the two noted features, a whole set of other technical characteristics, including the collection of data and strategies for data analysis, must be included in Yin's technical definition. In his view, the case study inquiry

- "copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result
- relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result
- benefits from the prior development of theoretical propositions to guide data collection and analysis" (ibid).

With these two defining elements in place, the case study is seen as a comprehensive research strategy comprising an all-encompassing method that incorporates specific approaches to data collection and analysis.

Concerning their purpose, case studies can be descriptive, exploratory or explanatory. Descriptive case studies aim to describe the incidence or prevalence of features pertaining to problematic situations. Exploratory case studies focus mainly on *what* questions pertaining to problematic situations. Such questions can be a justifiable rationale for developing pertinent hypotheses and propositions for further inquiry into the situations. Explanatory case studies focus mainly on *why* and *how* questions pertaining to problematic situations. Such questions deal with operational links between components of situations needing to be traced over time.

4.3 Phase 3: Constructing Hypothetical Solutions to Problem Situations

Following Field, in "the third, reflective phase of the process, the cognitive elements of inquiry (ideas, suppositions, theories, etc.) are entertained as hypothetical solutions to the originating impediment of the problematic situation, the implications of which are pursued in the abstract" (Field 1996: 4). Concerning the cognitive elements of inquiry, Dewey said that "knowledge (….) is a name for the product of competent inquiry" (Dewey 1938: 8). However, due to all the metaphysical connotations the term knowledge carries in traditional philosophy Dewey hesitated to use it. Rather, he talked of successful inquiry as producing *warranted assertions*. "In selecting this language", Bush argue, Dewey "sought to emphasize the idea that inquiry is an ongoing process" (Bush 1993: 64).

Warranted assertions are beliefs that function as the starting point of the next stage of inquiry. "There is", Dewey says, "continuity in inquiry. The conclusions reached in one inquiry become the means,

material and procedural, of carrying on further inquiries" (Dewey 1938: 140). This does not mean, however, that warranted assertions, once they are established, are beyond further scrutiny. Rather, he says; "Attainment of settled beliefs is a progressive matter; there is no belief so settled as not to be exposed to further inquiry" (ibid.: 8). Thus, its correspondence to an ultimate, comprehensive truth can not be the basis upon which the value of knowledge is appraised; rather, Bush argue, "it is to be appraised for the instrumental capacity it possesses for the solution of problems" (Bush 1993: 64). This pragmatic position on knowledge "is the antithesis of foundationalism" (ibid.). This derives from "A fundamental tenet of pragmatism", viz. "that all propositions are subject to revision as theoretical and empirical inquiry moves forward" (ibid.: 59). Therefore, Bush argues, methodology must be under constant scrutiny so that the required revisions may be conducted at any given stage of inquiry.

A central activity within social inquiry involves the creative generation of hypotheses of possible and plausible causal determinants. Following Tool, the most dynamic and critical function of hypotheses is their directive role; "to guide inquiry and suggest what sorts of evidence to gather and the testing of hypotheses by overt or imaginative action to assess their explanatory capabilities" (Tool 1994b: 153). Dewey emphasized three aspects of conceptual subject matter (or theory) which start with:

> "(1) the status of theoretical conceptions as hypotheses which (2) have a directive function in control of observation and ultimate practical transformation of antecedent phenomena, and which (3) are tested and continually revised on the ground of the consequences they produce in existential application" (Dewey 1938: 506).

In the words of Bush, Dewey "regarded the capacity of a hypothesis to offer coherence and understanding as more important than its ability to formulate descriptive propositions that could be tested by their correspondence with the facts" (Bush 1993: 74).

At this point in the exposition of the process of inquiry, I would like make a very brief but possibly informative detour. This is in order to bring attention to a conception of knowledge production based on social practice introduced by Dewey's teacher in logic at Harvard, Charles Sanders Peirce. He argued that

> "there occurs in science and in everyday life a distinct pattern of reasoning wherein explanatory hypotheses are formed and accepted. He called this kind of reasoning 'abduction', a form of inference that goes from data describing something to a hypothesis that best explains or accounts for the data. Thus abduction is a kind of theory-forming or interpretive inference" (Tanner and Josephson 1994: 5).

As Campbell (1995) has pointed out, Dewey was particularly interested in Peirce's emphasis on the engagement of humans in "cooperative attempts to overcome our intellectual problems" (ibid.: 15). He was also shared Peirce's belief that a more adequate theory of meaning should be developed in order to "develop more precision in our philosophical formulations" (ibid.: 16). This is reflected in his concern with reconstruction of philosophy and the idea that philosophy and thinking should make practice more intelligent. In addition to this, although Dewey hardly uses the term, I think the notion of abduction fits well with his own version of pragmatism where he combined the inquiring and critical spirit of Peirce in a generally scientific approach to social and moral issues.

Concerning explanatory reasoning, a distinction is usually made between induction and deduction as mutually exclusive alternatives.[12] In induction, the inference is from particular instances to general rules, while in deduction the inference is from general rules to particular instances. Most significantly, Peirce (1934) stated that induction and deduction, either jointly or severally, could not account for the progress of scientific inquiry. That effectively was preserved for the third mode - abduction:

[12] In *How We Think* (1910) Dewey discusses these modes of reasoning.

> "Abduction is the process of forming an explanatory hypothesis. It is the only logical operation which introduces any new idea; for induction does nothing but determine a value, and deduction merely evolves the necessary consequences of a pure hypothesis" (ibid.: 106).

Inductive inference starts from empirical material, while deduction starts from theory. Abductive inference starts from empirical facts as induction, but does not reject theoretical conceptions, and is therefore closer to deduction. However, abduction includes aspects of understanding in addition to pure explanation. I will not pursue the concept of abduction any further here, only argue that this mode of reasoning most probably was an important influence on the development of Dewey's own theory of inquiry. My point is that an account of inquiriental activity as understood by Dewey also means to elaborate on what it implies to reasoning abductively, i.e. hypothetically, whether in scientific or everyday problem solving.

Here, I return to an elaboration of the practical implications of conducting inquiry provided by Marc Tool. He says that this process "consists mainly of a continuous ordering and juxtaposing of explanatory constructs and factual evidences of indeterminateness in quest of that causal accounting that most adequately and simply explains observed phenomena" (Tool 1994b: 153). In this process of combining theoretical and empirical subject-matter, the instrumental character of pragmatist inquiry is clear because the tools of inquiry "are borrowed or created and employed as instruments of disclosure and appraisal; they are revamped as required to facilitate the inquiry process. Instrumental inquiry encompasses those activities which create and facilitate the application of warranted knowledge as outcomes of prior inquiry" (ibid.: 153-154). To bring the process of inquiry forward, judgments as to what will accomplish this must be made. Judgments with these consequences are instrumentally warranted and reflect «the creation and/or selection of the relevant constructs and intellectual tools and techniques for inquiry. Such judgments define the need for, and direct the creation of, new conceptual tools as required to move the inquiry along" (Tool 1993b: 130).

In this work, the creation, in imaginative ways, of analytical constructs that become operational tools of new theoretical inquiries is of central importance. Such analytic constructs must, following Dewey's *Logic of Inquiry* (1938), satisfy the *conjugate relation* or *conjugate correspondence* that must hold between the empirical and theoretical dimensions of inquiry. Dewey expressed the relation between these dimensions as follows: "Observation of facts and suggested meanings or ideas arise and develop in correspondence with each other" (ibid.: 109). As I have pointed out, the pragmatic instrumentalist view on the choice of meanings, ideas or theories in the social sciences comes down to one thing according to the Dewey scholars Tool and Bush.

In Tool's words, the «choice of a conceptual tool is determined by its ability to function appropriately to inform, and instrumentally to correct, in the role assigned» (Tool 1993b: 131). In Bush's words "competing theories must be judged on their capacity to transform an indeterminate situation into a unified whole; that is, they must be evaluated for their capacity to contribute to the problem-solving processes of real, living communities» (Bush 1993: 96). However, rather than searching for formal criteria by which to select among competing theories, within the pragmatic instrumentalist approach the focus is instead on «a means-end continuum in which theories are viewed as a means to the ends-in-view of inquiry» (ibid.).

Concerning the choice of meanings, ideas or theories as problem solving tools, Field (1996) says in more abstract terms that:

> "The final test of the adequacy of….solutions comes with their employment in action. If a reconstruction of the antecedent situation conducive to fluid activity is achieved, then the solution no longer retains the character of the hypothetical that marks cognitive thought; rather, it becomes a part of the existential circumstances of human life" (ibid.: 4).

Therefore if inquiry is successful, the indeterminate situation is transformed into *a determinate whole* and inquiry is terminated "in the institution of conditions which remove need for doubt" (Dewey 1938: 7). To sum up the point that connects part three and four of this essay, the main reason that inquiry can be called technological is that "it is the means of effective control of an environment that is not what we wish it to be. Inquiry is in this way differentiated from other forms of activity. It produces something new as a means of changing situations that are not what we wish them to be" (Hickman 1990: 41). By taking this view, I think that the pragmatist theory of inquiry provides relevant insights into the issue of what is the nature of invention, innovation and creativity in the conduct of social life.

4.4 Continuity of Situations - Frameworks of Activities

Instrumentalism stresses particular situations as forming a setting or strategic research site where inquiry takes place. The reality experienced by actors can be seen as a continuity of such situations. For the purpose of inquiry, we can speak of a consecutive history of situations experienced as indeterminate - problematic - determinate - indeterminate - problematic - determinate, etc., etc. In addition to situations following one another in time, actors will of course also experience several situations in parallel at the same point in time. In any case, all current and past situations are the result of historical processes and cumulative change and we need to acknowledge and understand this character of the settings to be investigated.

Since time is moving in only one direction, it is impossible to reverse such processes or begin at the beginning. The inquirer has to cut in at a certain point in the continuum, depending on the nature of the inquiry undertaken. At such points of entry, the inquiry starts with either observation of performance in current situations or efforts to reconstruct past situations. While searching for relations between elements of situations, hypotheses are developed out of the observations or reconstructions. As Peirce said, the inquirer should study the facts and devise a theory to explain them.

As Dewey always emphasized, human behaviour must be analyzed and understood as purposeful. With his concept of active productive skill, he specifically focused on the role of purpose in understanding and solving human problems in particular situations. Therefore, issues pertaining to purpose or motivation of why people behave as they do must be addressed in instrumentalist inquiry. While some understanding of purpose must precede inquiry, it is neither purely antecedent nor separate from the specifics of the situation and context inquired into. In instrumentalism, behaviour is conceived as a resultant of innate factors conditioned by habits, thus making social institutions a main ground for social explanation. This means that knowledge of the particular institutional structure of a situation contributes to understanding behaviour that result from this structure. Therefore, the instrumentalist inquirer is focused upon social institutions governing particular situations.

The structure of institutions at any specific time and in any specific situation is purely a historical fact. It can be explained in terms of cumulative change from pre-existing institutions evolving under the influence of those factors that tend to modify habit in one direction or another. As pointed out by institutionalists in the tradition of Deweyan instrumentalism, for instance Thorstein Veblen (1899), institutions have a history, they are changing through ongoing processes of evolution and they are made up of conflicting interests. If an understanding of individual action is attempted, we must look to the institutions to frame the investigation. Thus, the context or situation within which activity takes place should be seen as a particular institutional setting. Therefore, understanding the framework, setting or conditions within which something happens is a central issue in instrumentalist inquiry.

It is clear that social behaviour assumed to be purposeful is set within the context of prevailing institutions with specific histories. We should also acknowledge that change occurs as external

situations change and new problems arise or different conflicts emerge. However, it is not likely that all the parts of an organization will change or that those which do will change at the same rate. Therefore, the focus must be upon those particular conflicts or those strategic factors that seems most important in addressing the research question. Since an organization may be very complex and since it may interact with other organizations, it is impossible to have total control over its direction.

Therefore, actors tend to identify those strategic factors that they consider to be limiting the performance of the organization for their purposes and attempt to remove those factors. Of course, events beyond purposeful action will also affect the performance, but purposeful responses to exogenous events will direct the evolutionary process. Moreover, because organizations are amalgams of individuals each seeking to control the strategic factors for certain purposes of their own, we must also consider that the structures governing particular situations are the results of some form of negotiations.

It is this process of identification and attempted control of limiting factors, and the need to attend to new limiting factors that largely defines the sequence of activities of organizations and the impetus for change. Such sequences of activities and the frameworks within which they take place are at the core of instrumentalist inquiry. Inquirers must focus upon the particular problem that is the limiting factor at a particular time in a particular situation. To focus on the settings or frameworks of activities implies to identify "the parameters within which the reconstruction of the initiating situation must be addressed" (Field 1996: 4). By narrowing the inquiry to such critical factors, inquirers may understand the development and functioning of complex technological and other social systems.

5 SUMMING UP

This essay has been a four-step inquiry into technology and inquiry. First, I introduced the field of science, technology and innovation (STI) studies. Second, in order to account for two instances of using active productive skills, I presented two basic elements of Dewey's philosophy. Third, I focused upon active productive skills in the production of material artifacts, commonly termed technology. In addition to informing the understanding of scientific practice, these insights also provides conceptual subject matter pertinent for inquiry into technologies. Fourth, I focused upon active productive skills in processes which artifact is *knowing,* viz. social scientific inquiry.

Through this account, the technological character of inquiry that Dewey thought significant has been disclosed: "Dewey thought that *every reflective experience is instrumental to further production of meanings, that is, it is technological*" (Hickman 1990: 40-41. Emphasis in original). Moreover, as Michael Eldridge has pointed out "Dewey regarded inquiry as a way to transform our experience. It occurred in time and made a difference existentially" (Eldridge 1998: 24). The theme of transforming experience, understood as a continuity of situations, is expressed in Dewey's idea that "scientific subject matter grows out of and returns into the subject matter of the everyday kind" (Dewey and Bentley 1949: 291).

In his account of Dewey's instrumental philosophy, Hickman has conceptualized this *growing out of* and *return to* everyday experience as the *excursus* and *recursus* of productive inquiry, as Eldridge observes (ibid.: 40). In Eldridge's words, then, instrumentalism can be usefully summed up as

> "the awareness that one's ideas are mental products drawn from life, and also the commitment on the part of the inquirer to return them to everyday experience. He or she uses hypotheses, theories, or ideals to inform the problematic situation, making it more satisfying. Instrumentalism is the opposite of the decontextualized thinking that Dewey deplored" (ibid.).

Such use of hypotheses, theories and ideals to inform problematic situations was, as far as I understand Peirce, what he had in mind when coining the term abduction.

In part four, I also outlined the continuous process of contextualized, instrumental, productive inquiry as consisting of three phases. There the focus was on social scientific practice. However, given that Dewey's methodology or theory of inquiry grew out of his technology conception, it is my conjecture that the three-phased conception of a process of scientific inquiry is also applicable to a process of producing technological artifacts. This means that the two different instances of using active productive skills - in producing both concrete, physical and abstract, mental artifacts - can be understood in the same way, viz. as a continuous problem-solving process in which successive phases can be identified. The three phases in this process can be summarized in the following general terms:

i) The first phase of problem solving starts with an *indeterminate situation*. These situations arise out of encounters with resistant reality, constituted by a continuity of situations. Moreover, they are experienced as different patterns of resistance varying according to the details of the situation. Out of the effort to apply productive skills to such situations, *the problematic situation* arises. The point is that problematic situations are cognitive constructions that come into focus as inquiry is brought to bear on the indeterminate situations experienced in the conduct of life. Since problems do not define themselves pre-cognitively, they must be conceptualized through the utilization of all the theoretical and practical tools of coordinated inquiry.

ii) The second phase of problem solving involves the collection of the data or subject matter that defines the parameters or framework within which the reconstruction of the problematic situation must be addressed. Through a process of inquiry, the problem solver has continually to make appraisals both of the information gathered from own observations and from the findings of others. This has bearing upon what problems to undertake and what further activities of observation, experimentation and interpretation to carry out. In terms of the present inquiry, strategic research sites are the locations at which the empirical subject matter of problematic situations can be identified, collected and inquired into.

iii) In the third phase of problem solving the cognitive elements of inquiry (ideas, suppositions, theories, etc.) are entertained as hypothetical solutions to the originating resistant conditions of the problematic situation. A central activity involves the creative generation of hypotheses of possible and plausible causal determinants. The most dynamic and critical function of hypotheses are their directive role; i) in guiding inquiry; ii) in suggesting the kind of evidence to gather; and iii) in testing hypotheses by overt or imaginative action to assess their explanatory capabilities (Tool 1994b).

Based on this, the continuous ordering and juxtaposing of explanatory constructs and factual evidences implies that the tools of inquiry are borrowed or created and employed as instruments of disclosure and appraisal; they are revamped as required to facilitate the problem solving process.

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