

# Zimbabwe Journal of Educational Research

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# **An Analysis of Dewey's Perception of Science and Technology in Society: Relevance and Implications for an African Science and Technology Policy for Social and Economic Development.**

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## **Abstract:**

*This paper represents an attempt to describe Dewey's representative thoughts on the role of science and technology education in society. An attempt is made to demonstrate the relevance of his thinking to a justification and critique of an African nation's science and technology policy for social and economic transformation. The paper concludes by identifying aspects of national science and technology policy that have direct relevance to science education and by identifying problems that typically undermine the intents and purposes of science education in the secondary school system in Zimbabwe.*

## **Introduction:**

In his philosophy John Dewey places much premium on the impact that science and technology have on society, both in facilitating or militating against democracy. In 1927 he wrote in *The Public and Its Problems* (127):

Our concern at this time is to state that the machine age in developing the Great Society has invaded and partially disintegrated the small communities of former times without generating a Great Community .

At face-value it appears ironic that present day societies including developing nations implicitly seek to use technology as a way to transform society and as a way to build democratic principles. A survey of the contemporary science education literature will reveal the following broad emphases purported in science globally.

- **Emphasis on science education for all citizens so that they may be knowledgeable participants in solving problems and making decisions in an increasingly science and technology driven society.**
- **Emphasis away from teaching of science as a body of knowledge towards inquiry in which increasing emphasis is on students experiencing the processes and procedures of science.**
- **Emphasis in teaching science as inquiry (processes) and teaching science by inquiry (using the process of science to learn science).**
- **Emphasis on learning science taking into account the prior conceptual framework of students and providing students with experiences that lead to conceptual change and development.**
- **Emphasis on developing science skills that mirror the skills and processes essential to cope in an increasingly technological world and hence the emphasis is on using scientific and technological knowledge to solve problems and to make decisions.**
- **Emphasis on developing citizens who understand science in multidimensional, integrated multi-disciplinary ways that will enable them to participate intelligently in critical thinking, problem solving, and decision making about societal and personal issues.**
- **An emphasis on developing an awareness of social, ethical and moral problems and issues related to science and technology.**

This paper attempts, firstly, to provide an account of John Dewey's thinking with reference to science and technology. Specifically, it deals with issues related to the above purported emphases of science education. Secondly, it attempts to draw implications for science and technology education policy of an African country, Zimbabwe.

Zimbabwe's science and technology policy, which exemplifies policy in many less developed countries, is one which seeks to utilise scientific and technological knowledge for social and economic transformation. It is stated as one of the strategies in the *Second Five Year National Development Plan (NDP)* (1991-1995, 6) that:

The development of science and technology is Zimbabwe's long term and most important strategy for economic and social development.

Further, it is intended in Zimbabwe's national development plan to inculcate principles of democracy by reducing poverty and by improving the living and material conditions of the public. As a strategy for this line of development, authors of the NDP (1991-1995, 3) wrote:

Government will promote people's participation in economic and social development of the country since the process of development cannot take place without the active and full participation of the people. *People's participation is the foundation for self-reliant and self-sustained development* (emphasis added).

This quote underscores the relevance of the preceding broad aims of global science education and Dewey's philosophy in the context of Zimbabwe. John Dewey, writing essentially for the American society of the time, addresses social issues such as the community, democracy and the relationship between science and technology with society many of which appear relevant to many developing countries at this stage of their development. In particular the statement in the Zimbabwe's NDP that "People's participation is the foundation for self-reliant and self-sustained development," appears remarkably Deweyan. Zimbabwe is in the early phases of industrialization making Dewey's thoughts expressed during a

time when the pace of industrialization in western countries was picking moment. Interwoven in the national development plan is the principle of education with production also not contradictory to Dewey's idea of the connectedness between theory and practice. In Zimbabwe and other countries, education with production in the curriculum is an attempt to engage students in economically purposeful productive work and socially useful activities alongside academic and theoretical study (*International Foundation for Education With Production (FEP), 1990; 1*).

Whilst in general, Dewey's writings are pregnant with his thoughts about various societal issues, this paper dwells only on his teachings that can be related to science and technology education. In a foreword to Larry Hickman's *John Dewey's Pragmatic Technology* Ihde (1990) wrote that Dewey's instrumentalism has often been overlooked "yet Dewey is, par excellence, the American 'father' of the philosophy of technology" (viii). According to Hickman (1990) "only Dewey was able to construct a responsible (sic) account of technology" (xi). Although it is further claimed that "John Dewey's critique of technology, an enterprise he carried out during more than half a century and more than 13,000 published pages" (Hickman 1990; xi), only five of Dewey's original works serve as the primary sources for the discussion. The original works include *The Public and its Problems*; *Experience and Education*; *Democracy and Education*; *The School and Society*; and *Child and the Curriculum*. The major secondary sources used in this paper are Mayhew and Edwards' (1936) account of *The Dewey School* and Thelen's *Education and the Human Quest*.

The selection of Dewey needs little justification. It suffices to paraphrase some of his thoughts that appear relevant to global science education emphases cited earlier. The following strike me as a reasonable sample of examples.

- Emphasis on education for all of society's youth so that they may be skilled and knowledgeable participants in societal occupations.
- Emphasis on teaching as counselling in which increasing emphasis is on students building upon their interests and experiences. Inquiry or the

processes and procedures of science are to be approached through discovery.

- Inquiry processes characteristic of the physical sciences should become the modus operandi of education in all social sciences and in daily living.
- Skills developed in science and other school subjects must mirror the skills essential in the social occupations.
- A multi-disciplinary approach that took into account the developmental level of children was to be favoured over single subject approaches to curriculum organization and instruction.

The other justification is that Dewey was among the first to confront the issue of education and praxis. According to a quote in Mayhew and Edwards (1936, 16) Dewey (1904) stated:

Utility and culture, absorption and expression, theory and practice are indispensable elements in any educational scheme.

Further Dewey wrote about the "the fatal split" in education which persists to this day:

For genuine intellectual development it is impossible to separate the attainment of knowledge from its application. The divorce between learning and its use is the most serious defect of our education (in Mayhew and Edwards, 1936; 33).

## **Perceptions on Technology**

Prior to the rest of the discussion, it is necessary to provide a synopsis of Dewey's views on science and technology in order to illustrate the standpoint taken throughout the paper. For Dewey, technology in addition to material objects and machines includes immaterial objects

such as ideas, theories, numbers, and objects of logic (Hickman, 1990). Regardless of whether the technology was a machine or an idea it still remained umbilically tied to its function, application and use in solving societal problems. Ideas like machines, to which they are metaphorically compared, are artifacts or tools useful only by what one does with them in society. According to Hickman (1990; 22):

He [Dewey] thought 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.

That Dewey considered ideas or theories as technology or artifacts apparent in the following quote taken by Hickman (1990, 301) from *Experience and Nature*.

The idea is, in short, art and a work of art. As work of art, it directly liberates subsequent action and makes it more fruitful in a creation of more meanings and more perceptions.

Hickman (1990, 4) also makes an observation that Dewey considered technology as being synonymous with methods of inquiry. He asserts:

He [Dewey] was concerned with how tools and instruments come to be, how they change human experience, and what they portend. But even more fundamentally, he sought to demonstrate the methods and means by which technological inquiry takes place are the methods and means by which all knowing, in its 'honorific' sense is generated.

In both *Experience and Education* and *The Public and Its Problems*, Dewey's examples of method of inquiry are drawn mainly from physical science. In either case, systematic inquiry characteristic of physical science is expected to be employed in the social science as a way to understanding the public and its problems, and as a way to provide or to develop solutions for social advancement. The germane point to be made

is that Dewey's method of inquiry was intended as a means by which societally relevant problems could be solved. He, therefore, envisioned technology in terms of active and productive inquiry whose results should ultimately be applied to improving the community's well-being. As Hickman (1990, 40-41) is quick to note, "*every experience is instrumental to further production of meanings, that is, it is technological*" (emphasis in original). Dewey viewed technology as an application of science which itself tended to be the more theoretical in scope. In *The Dewey School* Mayhew and Edwards (1936, 32) stated:

Another aspect of the science studied is the application of natural forces to the service of man (sic) through machines.

On this basis science and technology were seen as connected, one representing theoretical knowledge and the other representing application of this knowledge. Today, the tendency to make education 'technological' is apparent in goals that emphasize that skills developed in science must mirror the skills of problem solving and decision making essential to cope in an increasingly technological world.

Another important assumption in Dewey's philosophy is that technology is an instrument of control and that social control was essential for freedom and democracy. This theme is abundantly evident in the closing chapters of *The Public and Its Problems* in which social control is seen as essential for the basic functioning of society. Today's science education is characterised by goal statements such as meeting personal needs, career awareness, and preparation for the world of work whose common thread is their focus on controlling one's social and technological environment. It is from this utilitarian stance that his ideas may be relevant to developing countries whose present fundamental concerns with technology is with its use in production (Rosa, 1984; Ventura, 1984; Burhop, 1981; MEC, 1992, FEP, 1990).

### **Societal Problems and Production**

For Dewey, technology was useful in so far as it was applied to address society's problems but cautions about science and technology as panacea

for all of society's problems. In *The Public and Its Problems* Dewey expressed the dichotomous nature of science and technology:

Steam and electricity have done more to alter the conditions under which men associate together than all agencies which affected human relationships before our time. There are those who lay blame for all evils of our lives on steam, electricity and machinery. It is always convenient to have *a devil as well as a saviour* to bear the responsibilities of humanity. In reality, the trouble springs rather from the ideas and absence of ideas in connection with which technological factors operate (141; emphasis added).

The extent to which both the impact and consequence of science and technology permeate the rest of society depends on how students are made to experience it in their years in school. In *Experience and Education* Dewey optimistically suggested how this might be accomplished:

It is sound educational principle that students should be introduced to scientific subject matter and be initiated into its fact and laws through the acquaintance with everyday social applications. Adherence to this method is *not only the most direct avenue to understanding science itself* but as the pupils grow more mature *it is also the surest road to understanding of the economic and industrial problems of present society* (80; emphasis added).

Unlike traditional education which relied upon subjects for its content, progressive education relies on learners needs and the current problems of society. It is within this line of logic that contemporary science education emphasizing applications, and hence relevance is to be appreciated. On this point Dewey's thinking is that sound educational principles involve continuity and interaction between the learner and what is learned. He therefore states:

The utilization of subject-matter found in the present life experience of the learner towards science is perhaps the best illustration that can be found of the basic principle of

using existing experiences as the means of carrying learners on to a wider, more refined, and better organised environing world [sic], physical and human, than is found in the experiences from which educative growth sets in (*Experience and Education*; 82).

### Impact of Science and Technology on Society

This line of argument is developed further and justified with reference to the impact of science and technology on society, a central concern in modern science education rhetoric and research. Dewey emphasized the role of technological and industrial factors as illustrated in *The Public and Its Problems* where attempts to deal with the effects of industrial forces is evident.

What actually happens in consequence of industrial forces is dependent upon the presence or absence of perception and communication of consequences, upon foresight and its effect upon desire and endeavour (156).

It is the role of education to ensure that these perceptions, interests and foresight are communicated to all of society's youth. Dewey does not himself believe in science for 'scientific workers' which he describes as "a mastery in the hands of initiates, who have become adepts in virtue of following ritualistic ceremonies from which the profane herd is excluded" (164). It was true then as it is now that this majority of students whom he called 'the profane herd' would experience science mainly in its application and manifestation in technology or appliances:

...the reality of the apparatus is found only in its *embodiments in practical affairs, in mechanical devices and in techniques that touch life as it is lived* [my emphasis]. For them, electricity is *known* by means of the telephones, the bells and lights they use... (*The Public and Its Problems*; 164).

It is within this context that he is advocating for science education for all; a science education that is linked to the activities of the community, a science education that is context-embedded in real-life experiences and

practical applications. Because of the great impact of science on society, Dewey therefore underscored the importance of understanding this interaction between science and technology as a goal of education.

At his time the predominant school science subject, physical science which was accessible to only a few students failed to show this desired relationship. He assessed the potential consequences in terms of control:

They do not understand *how* the change has gone on nor *how* it affects their conduct. Not understanding its "how," they cannot use or control its manifestations (165).

Science education should therefore ensure that students comprehend the impact of science and technology on society, especially those aspects that were immediately observable in their communities. This leads to meaningful learning, a point that Herbert Thelen (1960) pointed out with reference to the role of the school:

The thing that makes the school "educational" is its concern with knowledge. The school is expected to go beyond conditioning to understanding... The school testifies to our faith that man and society can be improved, and that the way to improvement is through trained use of intelligence. (29).

For Dewey, in order for maximal and effective sharpening and improvement of the 'useful' intelligence, experience in formal education would need to closely resemble those in real-life application. It is this concern that made him advance the requirement for an integrated relationship of the disciplines or academic subjects not only among themselves but also their integration with society.

## **Integration and Interaction of Subject Matters**

John Dewey clearly perceived the significance and ultimate utility of having integration, interaction and 'cross-fertilization' of subject matters. In his time, this was most readily exemplified by the physical sciences. He therefore proposed that subject matters of the social sciences must integrate and interact among themselves and with the 'physical'

knowledge. Dewey's assessment, which is also evident in today's debates, was that:

The backwardness of social knowledge is marked in its division into independent and insulated branches of learning. ... The isolation of humane subject from one another is connected with their aloofness from physical knowledge (*The Public and Its Problems*; 171).

The relationship between physical and social sciences is one to which Dewey was full of advocacy. For example, he perceived that by relating science to real-life experiences within the community one could demystify the physical sciences and at the same time make them less technical. This conviction is expressed in this assertion in which utilitarian expectations are echoed:

When we say that a subject of science is technically specialized, or that it is highly "abstract," what we practically mean is that it is not conceived in terms of its bearing upon human life. All merely physical knowledge is technical, couched in a technical vocabulary communicable only to a few. Even physical knowledge which does affect human conduct, which does modify what we do and undergo, is also technical and remote in the degree in which its bearings are not understood and used (*The Public and Its Problems*; 172).

Integration was absolutely essential for knowledge to have social impact. Dewey expected this impact of knowledge to be judged based upon its utility in the functioning of the community. The idea of 'application' was itself symptomatic of and signified the bearing upon human experience and well being of what students were taught. He chastised the divorce or separation between pure and applied science for the reason that:

... honour for what is "pure" and contempt for what is "applied" has for its outcome a science which is remote and technical, communicable only to specialists, and a conduct of human affairs which is haphazard, biased, unfair in distribution of values. ... Science is only converted into knowledge in its honourable and emphatic sense *only* in

application. Otherwise it is truncated, blind, distorted (*The Public and Its Problems*; 174).

The glorification of 'pure' science was to Dewey a "rationalization of an escape; it marks a construction of an asylum of refuge, a shirking of responsibility. *The true purity of knowledge exists when it is uncontaminated by contact with use and service*" (175; emphasis added). He perceived that this application of physical science should be in human concerns as opposed to being applied to them. Application in life signified:

... the science was absorbed and distributed; that it was the instrumentality of that common understanding and thorough communication which is the precondition of the existence of a genuine and effective public (*The Public and Its Problems*; 174).

It follows therefore that even in the times of Dewey, social [and economic] development and attainment of democracy were closely linked to a scientifically and technologically literate public. It was therefore the responsibility of education to develop and communicate an understanding of science to all individuals. The only test for experience lay in the ability to use what had been learned in society. Dewey makes it abundantly clear that "anything which can be called a study, whether arithmetic, history, geography, or one of the natural sciences, must be derived from materials which at the outset fall within the scope of ordinary life-experience" (73). Many African states appear to have missed this lesson. Even in post-colonial times standards of attainment and achievement continue to be defined in terms of institutional requirements of the former colonizing country creating a situation of an unbreakable cycle of both knowledge and resource dependency (see Rosa, 1984; Ventura, 1984; Lewin, 1990; Hountondji, 1982).

### 'Habitudes' as Outcomes of Education

In *The Public and Its Problems*, Dewey articulated that human beings operate on the basis of habits learned as the result of inquiry. Human experience cumulatively leads to habit formation. Dewey visualized habits as the tools or 'main spring' of human action and hence he wrote:

Habit is the main spring of human action, and habits are formed for the most part under the influence of the customs of a group. The organic structure of man entails the formation of habit, for, whether we wish it or not, whether we are aware of it or not, every act effects a modification of attitude and set which directs future behaviour. ... The influence of habit is decisive because all distinctively human action has to be learned, and the very heart, blood and sinews of learning is the creation of habitudes (159-160).

Dewey's sentiments are relevant to goals of science education in many less developed societies where the habits of doing things that are characteristic of either scientific or technological inquiry are often lacking, under-utilized or simply blurred by the traditional belief system. Dewey appears to consider both scientific and technological attitudes and attitudes towards science and technology simultaneously under formation of 'habitudes.' For example he writes:

Habits bind us to orderly and established ways of action because they generate ease, skill and interests in things to which we have grown used ... Habit does not preclude the use of thought, but it determines the channels within which it operates. Thinking is secreted in the interstices of habits (*The Public and Its Problems*; 160).

Concern with attitude formation is fairly pervasive in Dewey's works. In *Experience and Education* he articulated the criterion of continuity also in terms of habit formation and modification.

At bottom, this principle rests upon the fact of habit, when habit is interpreted biologically. The basic characteristic of habit is that every experience enacted and undergone modifies the one who acts and undergoes, while this modification affects, whether we wish it or not, the quality of subsequent experiences... It covers the formation of attitudes, attitudes that are emotional and intellectual; it covers our basic sensitivities and ways of meeting and responding to all conditions which we meet in living.

From many perspectives in science education, development and nurturing of scientific attitudes which are more cognitively inclined and attitudes toward science which are mainly emotion based is (or should be) a fundamental goal (Schibeci, 1983; Shrigley, 1983). Dewey's explanation, consistent with current research, in *Experience and Education* justifies why this might be so:

... there is some kind of continuity in any case since every experience affects for better or worse the attitudes which help decide the quality of further experiences, by setting up certain preference or aversion, and making it easier or harder to act for this or that end (37).

Furthermore Dewey suggests what should be another focus of all schooling by stating:

The most important attitude that can be formed is that of desire to go on learning. If the impetus in this direction is weakened instead of being intensified, something much more than lack of preparation takes place. (48).

In the 'information age' it will be necessary for individuals to re-learn skills needed in their daily lives and in their careers many times during their post-school lives. This argument has been used to justify the emphasis of thinking and process skills and positive attitudes in contemporary science education. Habits of inquiry exemplified in science are according to Dewey the epitome of problem solving in society.

### **Process of Inquiry versus Product of Inquiry**

Dewey suggested that the scientific method of inquiry is a method of intelligence. In *Experience and Education* Dewey underscored the need for a science education for all in which the scientific method is taught with:

... a view to making the method of intelligence, exemplified in science, supreme in education. There is nothing inherent in the nature of habit that prevents intelligent method from becoming itself habitual; and there is nothing in the nature

of emotion to prevent the development of intense emotional allegiance to the method (81).

Dewey's emphasis and regards for the method of inquiry underscores the significance of process as opposed to learning science as finished products. For him the relationship between the processes of actual real-life experiences and education is intimate and necessary. In *Experience and Education* he gives a vivid description and justification of what education and learning should be: "*education of, by, and for experience*" (29; emphasis added). The following quote represents, further, an example of the reason why academic content or product-oriented practices of traditional education were (and still are) not desirable:

... the gulf between the mature or adult products and the experience and abilities of the young is so wide that the very situation forbids much active participation by pupils in the development of what is taught. Theirs is to do - and learn, as it was part the part of the six hundred to do and die. Learning here means acquisition of what already is incorporated in books and in the heads of the elders. Moreover, that which is taught is thought of as static. It is taught as a finished product, with little regard either to the ways in which it was originally built up or to changes that will surely occur in the future (*Experience and Education*; 19).

The last sentence in the above quote underscores the importance of the process approach to science education and other subjects. In *The Dewey School* the issue is illustrated with reference to students being involved in authentic original research. In the school, efforts were made for students to experience and observe genuine problems in the community before proceeding to suggest and test potential solutions. Mayhew and Edwards (1936, 335) summed up the intents of the approach in the school with reference to the relationship of the method of inquiry to thinking.

The ability to think and the method of thinking are part and parcel of all reinventing and the rediscovering. ... Thinking does not occur for its own sake; it is not an end in itself. It

arises from the need of meeting some difficulty, in reflecting upon the best way of overcoming it, and thus leads to planning, to project mentally the end to be reassured, and deciding upon the stress necessary.

## History of Science

Dewey criticises scholastic systems that made the past an end in itself as opposed to making "acquaintance with the past as a means of understanding the present". Shumba (1993) reviewed research literature on the possibility of using history and philosophy of science in science teacher education courses as a way to nurture understanding the nature of science and technology. This too appears justifiable in Deweyan terms. Dewey asserts that the conditions in the past illuminate present experience and problems. He wrote:

The process is a continuous spiral. The inescapable linkage of the present with the past is a principle whose application is not restricted to a study of history. Take natural science, for example. Contemporary life is what it is in a very large measure because of the results of application of physical science. The experience of every child and youth, in the country and in the city, is what it is in its present actuality because of appliances [developed in the past] which utilize electricity, heat, and chemical processes (*Experience and Education*; 79).

It is within this light that students must at least be expected to understand how science has developed to what it is or to be able to predict "changes that will surely occur in the future". Further, these experiences serve to highlight societal applications by examining their evolution and longitudinal refinement over time. Dewey himself argued that students should be introduced to scientific subject-matter and be initiated into its facts and laws through the acquaintance with everyday social applications, especially how those applications came to be. He asserted:

Adherence to this method is not only the most direct avenue to understanding science itself but as the pupils grow more mature it is also the surest road to understanding of the

economic and industrial problems of present society' (*Experience and Education*; 80).

This approach would probably lead to the development of higher order learning as notable in his assertion that "intelligent activity ... involves selection of means - analysis- [sic] out of the variety of conditions that are present, and their arrangement- synthesis [sic] to reach an intended aim or purpose" (84).

*The Dewey School* attempted to demonstrate the idea that "the use of thinking is to manage experience" (Mayhew and Edwards, 1936; 222). This was based on teaching approaches that relied upon an historical comparative approach in which a study of the past, e.g. industrial development was related to the present. Dewey's overarching principle was that knowledge of the past was the key to understanding the present since the past is the history of the present. A study of industrial development was therefore seen in terms of its social and economic impact on the lives of people who lived at various historical times. According to Mayhew and Edwards, (330) "Industries largely affect the social life of the community, and the social life its history". While for example, the Zimbabwe Science 5006/7 contains a section on 'science in industry,' science curricula largely lack this relevant link between social life and history.

### **Summary of Problems in Science Education**

What the foregoing narrative has attempted to show is the apparent congruence of Dewey's ideas to problems affecting science education in contemporary society. The following are some of the things that come to mind as being recurrently problematic and which continue to preoccupy debate of science educators in many of their rhetoric and publications. For developing and developed countries alike, their solution would represent a major step toward the attainment of the goal of scientific and technological literacy. Dewey was among the first well publicized educators and philosophers to face up to their challenge. Some of those focal points are:

- Role of history, sociology and philosophy of science in which understanding the nature of science and technology today presupposes understanding its historical development.
- How best to balance the intellectual (academic and cognitive) aspects of study with the practical phases of experience in an attempt to boost productivity of individuals in society.
- How general education for *all* in science should be structured for maximal benefits to the prospective science major and non-major.
- Relationship of science and technology to societal development, in particular concern with slow paced development of the third world countries.
- How societal issues, occupations and the environment can serve effectively as sources of representative and overarching concepts and issues (idea of societal relevance and personal relevance) such as in science-technology-society courses.
- Extent to which the scientific method and the 'process' approach can penetrate society at large, particularly in problem solving and decision making.
- Identification of issues representative of a field of study when emphasis is placed on integrated and multi-disciplinary experiences and courses. Tied to this is how best to prepare teachers and how to staff science classes.
- How best to create equitable school-community relationships (resource sharing, participation in projects, and identification of the school with community occupations and interests).

Clearly the same issues that were pervasive in Dewey's thinking are the same issues that appear profound today. The reason why this is so has

been blamed on science education reform which was academic content driven. According to Duschl (1985) the discipline-oriented curricula were developed mutually exclusive of the history and philosophy of science. While Dewey is not readily acknowledged in the science education literature, the influence, relevance and contribution of his philosophy is abundantly apparent.

## Implications

The implications of the preceding analysis of Dewey's pragmatism for science educators, policy makers and government is made abundantly clear by none other than Dewey himself in *Experience and Education*, (50):

The persons who should have some idea of the connection between the two [experience and education] are those who achieved maturity. Accordingly upon them devolves the responsibility for instituting the conditions for the kind of present experience which has a favourable effect upon the future.

That Dewey's thinking would be relevant to Zimbabwe is illustrated in the following purposes appearing in the introduction to the compulsory science syllabus (*SS10 ZIMB (1992)*) at the Ordinary level of the secondary education system.

- Education, particularly at secondary level, should prepare the majority of pupils for the world of work while at the same time helping the minority high-achievers to qualify for institutions of higher learning.
- Incorporate within the education system values that are consistent with the social and political aspirations of Zimbabwe, e.g. inculcation of the work ethic and the usefulness of productivity, patriotism, cooperation and an understanding of Zimbabwean regional and world history, culture, politics and ideology.

- Incorporate social, scientific and technological content and concepts wherever possible across the curriculum so that this essential general knowledge is accessible to as many people as possible.

It is clear that the goals emphasize values, social utility, and productivity in society that are typical major themes in Dewey's teachings. It is my opinion that the current science education [if given appropriate resources] curricula can effectively support Zimbabwe's current science and technology policy and national development plans. Factors such as lack of training of science teachers in the new curricula; lack of curriculum materials and other resources; and uninformed conservatism blur and mask this potential. When these factors are taken into account, it is apparent that the problems gnawing at the quality of Zimbabwe's education system have very little to do with whether the curricula are relevant or valid from a theoretical, philosophical or pedagogical perspective.

Basing my argument on Dewey, I now turn the discussion to what I see as the direction science education should be taking in order to avoid the pitfalls experienced by those countries gaining independence two or so decades before us. Dewey once observed that there is "no public without full publicity in respect to all consequences which concern it". Zimbabwe's educators need to 'control' at least some of those consequences. Ventura (1984, 9) made an observation relevant for science educators in Zimbabwe to be aware of:

Many developing countries are now realizing that it is much harder to attain socio-economic independence than it was to achieve political independence.

It is necessary to have publicity for those issues as a necessary step toward seeking lasting solutions. Jose Gago (1991, 294) could not have put it more aptly when he wrote: "The future of science education will itself be the result of its own debate".

## Increasing Role of Science Education Research

Improved pace of national development, it seems, is more likely when it is based on the application of scientific research and its findings in social settings. It is therefore necessary to take a critical and reflective look at what science education has accomplished so far, cautious of the fact that science and technology education will not be panacea for all of society's problems. Science and technology education is serious business requiring large financial commitments and any changes to provision must be a subject of thorough and well publicized inquiry or research. In *The School And Society* Dewey clearly relates the significance of the school in developing scientific and social insight and values which must characterize society, its actions and its consequences:

... the scientific insight thus gained becomes an indispensable instrument of free and active participation in modern social life.

As a matter of fact, the economic consequences for failure to do so are also clearly articulated.

Until the instincts of construction and production are systematically laid hold of in the years of childhood and youth, until they are trained in social directions, enriched by historical interpretation, controlled and illuminated by scientific methods, we are in no even to locate the source of our economic evils, much less to deal with them effectively.

Hebert Thelen (1960, 217) expressed sentiments that would support this role of science education.

The significant product of science and education will be the incorporation within the human animal of the capability and habit of inquiry.

Further Thelen provides what is a relevant perception of science in relation to the education of all persons in society. This function is relevant

in being an all encompassing role of science education, not for serving the discipline of science *per se* but for community well-being.

What we call science is only the situation in which inquiry is easiest to demonstrate, explicate, and study. The engagement in scientific pursuits is only a role that some people play; *but the assimilation of the discipline of inquiry in all areas of life is the integration of the scientific function, through education, within the whole society* (217-218; emphasis added).

It is generally true that many of today's problems, food production, provision of shelter, pollution, and deforestation for example, require scientifically literate citizens.

### Shared Responsibility for Education

In order to popularize science and technology, it will be necessary to recognize and nurture the symbiotic and umbilical connectedness of the school and the community. As Dewey ably articulated in *The Child And the Curriculum*, the responsibility for developing and linking societal experiences with the activities within the school are clearly not the responsibility of schools alone. It is the responsibility to be shared among business and industry, university and technical and professional research institutions, parents, and others in society. This line of reasoning is also supported by Thelen (1960, 205) who stated that the community which "values and celebrates education will have an easier time improving the schools". The experience of school-business-community partnerships elsewhere should be empirically tried out.

The case for science and technology education clearly requires conscious effort and financial commitments to stir it towards the direction in which it can best fulfil its function of facilitating and bringing about social and economic transformation in Zimbabwe. Science and technology has not as of now penetrated the social and economic fabric deeply. According to Lewin (1990, 7), "science education is about development of human resources and not simply a layer of screening within the schools system". Several conditions in Zimbabwe will need to be considered and addressed

purposefully. Issues that appear to out-pace other priorities for immediate attention include curriculum resource provision, responsiveness of higher education, and the role of examinations.

### **Curriculum Resources**

Provision in school of appropriate curricula is not sufficient in itself for the development of a strong science and technology base at pre-college level. Material resource inputs such as textbooks and training and retraining of the human resource (instruction and supervisory) remain seriously in need of attention (see Nyagura and Reece, 1989).

The issue of resource allocation remains perhaps the most urgent for any meaningful 'sciencing' to occur. A necessary condition for the rise of modern science according to Dewey is "its increased attention to and utilization of instrumentation" (Hickman, 1990; 99). Historical precedent tells us that until empirical science becomes technological, until it began to take seriously the production and use of tools and artifacts for the purpose of enlarging the significance of objects and events, "it remained at the level of intellectual abstraction" (Ibid). Science would not have succeeded historically without the role of instrumentation in providing for active experimentation, active data collection and active manipulation. The implications are clearly that science cannot and should not attempt to be taught at any level without illustrative apparatus and tools. Lewin's (1990, 1) observation that "much science is being taught using materials that assume the existence of learning resources that are not available" is largely applicable to Zimbabwe albeit undesirably so.

### **Responsiveness of Higher Education**

Higher education needs to be more responsive to needed change and innovation, and should do so at the same pace with university/pre-college education if the two are going to remain effectively articulated and complementary. While the process of 'indegensizing' the science curricula has been rapid at school level, it has perhaps been too rapid for in-service and pre-service training where curricula change has been snail-paced. This observation is largely applicable to many African countries (Lewin, 1990). A consequence has been that trained teachers view their role not

as those of preparing students for the world of work but for more study at the next academic level, an image which institutions of higher education regardless of their mission appear to articulate. Another relevant observation is that while the secondary curriculum cycle has gone through integrated, combined, and core or extended phases of science education, none of these changes are apparent in the training colleges. Teacher training and university education as Lewin observed remains single subject, explaining partly the resistance often found to these innovations. The consequence is that students exit secondary school lacking skills needed in the world of work as well as in the academically-oriented higher education institutions. This leads to general apathy and disillusionment with schools and school science.

## **Examinations**

The major preparation of students should not be driven by academic examinations, as presently the case. In Zimbabwe, a less conservative estimate of the population to whom the examinations are geared is twenty percent at most. Unfortunately even for this 20%, by international standards they may not be scientifically literate. This was one finding of the Second IEA Science Study (Postlethwaite, 1990) in which Zimbabwe was one of the countries that provided students in population 2 consisting of 14 year-olds on average (Form twos). In terms of total score, Zimbabwe, Ghana, Nigeria, and the Philippines had the lowest scores on the science tests. The proportion of schools, eighty percent, in Zimbabwe scoring below the lowest school in the highest scoring country Hungary was too high. The lowest 20% of students tested were considered scientifically illiterate.

Data on the 1988-1991 'O' Level examination performance provided by the Examinations Branch (Harare) suggests that for Science 5006, the pass rate has been declining over this four year period. The pass rate for this compulsory subject is somewhere around 25%. While Dewey does not provide a solution to the problems of examinations, it is clear from other sources that examinations may not necessarily provide measures of desired outcomes (Lewin, 1984). If anything, they narrow the focus of courses to things that can easily be recalled and thus divorced from human issues and conduct. Only about 10-15 percent of the O level candidates

proceed to Advanced Level and even smaller numbers of students make it to higher education! Dewey's perception of the academic approach to education can be sensed from the following quote:

All merely physical knowledge is technical, couched in a technical vocabulary communicable only to a few. Even physical knowledge which does affect human conduct, which does modify what we do and undergo, is also technical and remote in the degree in which its bearings are not understood and used (172).

The school system has the major responsibility of ensuring that the population as a whole acquires science-based literacy and that this need of the population as a whole is "not overshadowed by the needs of the minority who acquire specific high level skills in science" (Lewin, 1990; 12). At any rate, examination performance data should be analyzed critically so that it helps both educational planners and teachers in their endeavour.

### **Control of Science and Technology**

Some of the problems in science education for a country such as Zimbabwe can be traced to the strategy used by colonizing countries to ensure that they had absolute socio-economic control of the colonized countries (Rosa, 1984; Ventura, 1984; Burhop, 1981). A common strategy was not to develop a science and technology base so that the major activities of the colonized countries involved export of raw materials and the import of consumer items, machinery and skills! The result has been a totally weakened science and technology capability. A misdirected education system can easily perpetuate this vicious circle. One way it can do so is through deliberate inbreeding of the value 'pure' hard-core science as opposed to a contextualized, applied and community linked science. A second way it can do so is to value and articulate only the role of academic and specialist preparation at the expense of general education for children (Lewin, 1990).

The consequence is an ill-informed and scientifically illiterate bureaucracy whose value and perception of the role of science and

technology is warped. Pualin Hountondji of Benin had a point in asserting that: "Like our [Africa] economy, our scientific activity is externally-oriented, governed by other societies' needs and problems and, therefore geared to an external input" (3). An education system can easily perpetuate this feeling of hopelessness to its citizens and hence will never be able to break the cycle of lack of control of science and technology. Further it can easily perpetuate the short-term solution of 'technology transfers' and 'import substitution' which can mistakenly be substituted for more desirable long term solutions which depend on a strong local science and technology resource base.

It is in this respect that Dewey's thinking is relevant. Dewey's philosophy is that technology is an instrument of control and that control is essential for greater freedom and democracy, and for productivity. Control facilitates the alteration of the course of events and is related to production, a point relevant to science and technology for national development through industrialization.

Even if the fact that problems of development have both local and international dimensions and that science is 'universal' are taken into account (Léwin, 1990), the 'transfer' approach would still not provide solutions because of the uniqueness of the context and needs to which the technologies are to be applied. This typically fails because the theoretical and practical development and testing of science and technology is carried out elsewhere. From a Deweyan standpoint, this division between the theoretical and the practical, and their further division from the context in which science and technology are eventually applied is "uneducative". First, it does not help in the development of training needs of local expertise. Second it perpetuates underdevelopment by nurturing scientific and technological dependence (Ventura, 1984; Rosa, 1984), and third it mystifies science and technology in the dependent states (Lewin, 1990)!

## Conculsion

Rosa (1984, 15) observed that science and technology are inseparable and universal tools of progress. Rosa contended that science policy complemented technology policy and therefore provides for scientific

training of science teachers, technical and research workers and most importantly "spreads scientific mentality". The implicit assumption is that for a nation to have control of science and technology, science and technology skills have to be nurtured early in the education system, an assumption which Dewey held. Burhop (1981, 24) was more forthcoming in identifying this need for control.

The crying need for the people of the developing countries is to establish a science and technology relevant and adapted to their own needs. They need technology but they themselves need to master it and make it their own that they themselves can influence its further development.

In order for science and technology to serve meaningfully the function of social and economic transformation, a strong pre-higher education base is essential.

I must conclude this paper by stating that developed countries did not develop because of Dewey's ideas but it appears that Dewey-like approaches propel education and spur developmental thrust in those countries. This paper attempted to show that there are windows of possibility in a third world country based upon an interpretation of Dewey's philosophy. At the very least, understanding Dewey's representative ideas or some other equivalent philosophy should enable educators in Zimbabwe to better understand the driving motives of contemporary curricula, particularly those involving science. It does seem certainly impossible for socio-economic transformation to occur without direct control of science and technology. Control of science and technology will be impossible with higher education which lacks strong pre-college science education base and in conditions in which lack of appreciation of the role of science and technology by the broader masses of people in society runs deep. Dewey's idea was to ensure broader awareness of science and technology in society.

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