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SOME METHODOLOGICAL/PHILOSOPHICAL PROBLEMS
IN SECONDARY SCHOOL SCIENCE EDUCATION

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ABSTRACT

An examination of common images of science and the scientist, and of some conceptions of 'science processes' in secondary school science, as depicted in texts, curricula and other public utterances, reveals the influence of certain traditions of philosophy/methodology. The methodological/philosophical positions associated severally with Bacon, Locke and Hume, and the Logical Positivists, are collectively designated as 'Methodological Reductionism' in this study, and are explored and found to be inadequate and/or misleading in the light of recent developments in the philosophy of science. Dissatisfaction with current school science is also found to be a consequence of adoption of narrow, 'functional' goals of science education. Difficulties also arise from: confusion of meanings of scientific terms in relation to their 'ordinary language' usage as contrasted with their specialised scientific usage; teachers' attitudes towards, and understanding of, the nature of science; and teaching methods which despite innovations, have remained essentially content-oriented, fact-laden, formal and didactic. It is argued that if science education is to regain its interest and become educationally more meaningful for students, then an alternative methodological/philosophical rationale for science and 'science processes' is desirable. It is suggested that the adoption of what is basically a Kuhnian epistemology may help to remove misconceptions about science and the scientist, and also help to surmount some of the current difficulties in the teaching of science. To facilitate and accommodate conceptual changes in science education, a teaching and learning strategy based upon Kuhn's notions of 'paradigm' and 'paradigm change' can be utilised. Because current science education is said to be overly formalistic and socially isolated, it is recommended that a multi-disciplinary approach may not only regain for science

its declining interest, but also produce future citizens who are better equipped to deal with science/technology/society problems and issues, and who will possess the cognitive and affective attributes needed for making a positive contribution within a science- and technology-based society.

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On my return to Massey University in February 1983, on the suggestion of Mr E.L. Archer, I approached Dr David Stenhouse with a view to his taking over supervision of the thesis. In the course of the research it has become apparent that, working independently from our different starting-points, we had already converged on substantially similar diagnoses of the perceived problems and possible remedy. Dr Stenhouse has kindly made available various items of his own theoretical research both published and in press, and where relevant, I have cited these works by explicit references in this thesis. Beyond this, many general methodological issues have been greatly clarified in the course of discussions, and I wish to place on record my grateful appreciation to Dr Stenhouse for his very substantial contribution as Supervisor of this work.

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INTRODUCTION

In recent times there has been a growing concern amongst scientists, science critics, environmentalists, educationalists, 'sociologists of knowledge', and some of the general public about the consequences of certain scientific and technological developments. This concern arises out of a state of affairs in which people everywhere fear the dangers, only recently apparent, of the uncontrolled advances in science and technology especially as they affect the society. While, on one hand, people are readily accepting the benefits and commodities resulting from the continuing scientific and technological developments, on the other, they are showing an increasing uneasiness brought about by the threat of overpopulation and resulting environmental pollution, depletion of non-renewable resources, inequitable distribution of wealth, and especially the many dangers of nuclear catastrophe. There are moral issues raised by certain lines of research, and questions about the relative economic value of some areas of scientific research, in relation to massive and urgent world and/or national problems. Furthermore, there is the mounting criticism of the wholesale adoption and application of 'scientific norms' in our thought and behaviour; and to some extent we are now witnessing a rejection of the 'scientific mode of analysis' by those who are concerned about the dehumanising effect of modern science and technology.

The problems associated with the impact of science and technology on society suggest that there is a need for the democratization of technological decision-making. One possible way to achieve this goal is through science education whereby an awareness can be developed that citizen participation in science-related policies is desirable. Science education can also, in turn, develop in future scientists an awareness of their social responsibility as part of their scientific activity. But science education is currently available to a large percentage of the people

and we could therefore expect it to be adequate and to be capable of meeting the needs as new problems arise. However, there are specific problems confronting not only scientists but also science educators.

The effects of the threat associated with scientific and technological developments are

- (i) a loss of confidence in science and scientists and
- (ii) a rise in suspicion and hostility towards science and technology.

Symptomatic of these are the 'drift' of students away from the sciences, and the emergence of various groups protesting against different activities and developments that are linked to science and technology. Such symptoms imply

- (i) that there is something wrong with/about modern science itself, and/or
- (ii) that science education is presenting an inadequate view of the nature of science.

Present indications are that science is under external pressure to put its house in order and to adapt itself so as to meet the needs of the future. In response to potentially dangerous changes in the biosphere, a world-wide environmental protection movement has sprung up. And this movement has done more than criticize activities and developments responsible for different types of pollution, health hazards associated with food additives, possible radioactive leakage from nuclear reactors, the nuclear arms race, physical destruction of the environment, etc., etc.. It has also forced people to rethink their dependency on nature. As a consequence, instead of the view that humanity should be engaged in a war against nature, such movements are providing a fresh view that emphasises harmony with nature. At the scientific level, this has led to studies aimed at understanding ecological

relationships. There is now an emerging appreciation of the complexity of these relationships. This means that not only the scientific community but society itself needs to reconceptualize science and technology in terms of recycling, renewability, the carrying capacity of natural systems, and so on.

While it may be, that the problems associated with science and technology are a result of a misdirected view of the relationship between nature and science, this thesis will attempt to show that science education is itself contributing to the problems. It will be argued that school science along with its translation into practice embody images of the nature of man as scientist, of scientific knowledge, and of the relationships between the two, which contribute to the problems. It will be shown that the philosophical/methodological foundations of science subjects as these are presented in schools, give rise to conceptions of science, science 'processes', and the scientist that are inadequate and misleading. Such an exercise as examining the philosophical/methodological foundations of school science will be largely inferential since textbooks contain few explicit statements of position on philosophical matters. Science textbooks may reflect the views of the authors but the authors themselves may not be entirely conscious of any particular philosophical position. It may be more reasonable to suggest that the current textbooks and science programmes are more likely to reflect generally accepted views and these views are collectively held by the practising school science community.

The overall situation can be separated into two groups of considerations: effects and possible causes. The effects of science and science education to be studied are:

- (i) decline in confidence in (and even some symptoms of hostility towards) science and technology;
- (ii) students' misunderstanding of science and

- dissatisfaction with school science;
- (iii) gap between understanding of science and the social and personal needs for such an understanding; and
- (iv) the drift from science subjects.

All these effects are interrelated in mutually causal ways. It will be shown that there is no one single, independent variable. There are several sources of the current problems associated with school science. These are

- (a) images of science and the scientist as held by students and teachers;
- (b) conceptions of 'science processes';
- (c) teachers' and students' understanding of the nature of science;
- (d) the influence of certain scientific doctrines such as scientism, reductionism, etc. on society in general;
- (e) schools' perception of the purpose of science education;
- (f) specialisation and fragmentation of school science;
- (g) teaching that appears to be formal, rigid and paradigm-bound; and
- (h) certain other closely related features of school science.

This thesis will attempt to show that the above mentioned characteristics of secondary school science reflect certain influences, in particular the influence of some of the tenets of science posited by traditional philosophers of science, especially Bacon, Locke, Hume and the Logical Positivists. For the purpose of this thesis certain traditions of science attributed to Bacon, Locke, Hume and the Logical Positivists will be collectively identified as the tenets of the "Methodological Reductionists". The term 'Methodological Reductionism'

is to be used merely as a designation for some features and not all the features and is not intended to be definitive of everything said by Bacon, Locke, Hume and the Logical Positivists. It is being used in a limited way in this study. By highlighting the weaknesses inherent in some of the traditions of science attributed to the 'Methodological Reductionists' it will be possible to expose the corresponding weaknesses in secondary school science. If it is to be assumed that aspects of the philosophies of the 'Methodological Reductionists' have influenced science educators' conceptions of science, 'science processes' and scientists, then to point out the fallacies/anomalies in the traditional interpretations of science should provide a basis for rejecting images and myths fostered within school science.

The problems associated with science and technology and the inability of science education to offer ways and means of not only understanding why the problems exist but how to alleviate them, are all matters requiring solutions for several reasons. Science and technology are of fundamental importance to society. Any drift from the sciences could well mean a decline, qualitatively and quantitatively, in the number of students selecting careers related directly to science and technology. A regular supply of scientifically and technologically skilled manpower is necessary for the existence and maintenance of most modern societies. The supply of manpower is not the only reason. The increasing interaction of the individual with science and technology and the nature of modern day scientific research especially in the field of molecular biology suggest that a population that is more scientifically literate is desirable. This does not mean that the citizen need to know about the molecular structure of dioxin, heat and pressure cycles of motor car engines, or the recombinant DNA process. The citizen should have sufficient knowledge to evaluate scientific and technological practices so as to counteract possible abuse of decision-making power vested in a few.

The purpose of this thesis is, therefore, to identify some of the weaknesses in science education and to suggest strategies of change. In Chapter one, I shall provide a brief outline of some of the reasons for the increasing concern about the implications and consequences of scientific and technological activities. The decline in confidence in science and the emergence of public suspicion of 'experts' would naturally affect people's image of scientists. This will be considered in the next Chapter and it will be shown that the image of the scientist fostered by school science lends support to the view that the purpose of science is to subjugate nature, that science is neutral and that students of science must strive to imitate the scientists by being 'objective', 'rational', 'emotionally neutral', etc.. The cold, impersonal image of the scientist will be shown to contribute to the drift away from the sciences; it will be also shown that such an image of the scientist has a strong appeal to certain types of science aspirants - aspirants who admire characteristics or behaviours that are devoid of emotions and feelings. It is claimed that Gagne's conception of 'science processes', upon which much of the curriculum development and instructions in science are based, have been influenced by the epistemologies of the 'Methodological Reductionists'. In Chapter three, I shall investigate the epistemological bases of Gagne's theory of the learning hierarchy, and attempt to show the extent of the influence of the tenets of the 'Methodological Reductionists'. In light of recent developments in the philosophy of science it will be possible to argue that a commitment to inductive empiricism, a tradition closely associated with the Methodological Reductionists, leads to a presentation of a misleading and inadequate view of 'science processes'. In Chapter four, I shall show that the legacy of certain aspects of the philosophies of Bacon, Locke, Hume and the Logical Positivists is inherent in school science as evidenced by the projection of such images as: science is

neutral, infallible, and true; the central role of science is to facilitate man's domination over nature, science will provide answers to all social and environmental problems; all scientific phenomena can be explained if they are reduced to physics and chemistry. The limitations resulting from a commitment to such views will be considered. In Chapter five I shall (a) examine the major goals of science education and then show the kinds of problems arising from these goals, (b) argue that the current practice of formal initiation into the dominant paradigm of science fails to make science education as educationally worthwhile as it ought to be, and (c) examine teacher attitude, training, and understanding of the nature of science in order to point out the need for improvement in these areas. In the final Chapter, I shall outline a possible strategy for change in the hope that this strategy may help to remedy or at least alleviate some of the problems now confronting secondary school science.