SCIENCE EDUCATION AND SCIENTIFIC ATTITUDES

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Introduction

Science has several dimensions. Traditionally, the overwhelming emphasis in the science curriculum has been on the content dimension. Consequently students obtained a narrow understanding of the scientific culture. The situation has improved somewhat in the recent years as a result of the development of modern science programmes. Greater attention is given to the nature of scientific enquiry through the promotion of active student participation in activity-oriented learning experiences.

In addition to the knowledge and process dimensions of science some recognition has been given to scientific attitudes and to developing these attitudes in students. It is generally maintained and accepted unquestionably that scientists uphold a set of common scientific attitudes. It is also pointed out that students by practising science in the manner of scientists will consequently adopt and internalize these attitudes.

The trend in current science programme is to develop attitudes considered to be "scientific" and therefore valuable. Gauld (1973:25) lists such things as the tendency to be objective, open-minded, unbiassed, sceptical and curious and the possession of a critical, questioning and rational mind. Many modern science curricula such as the local Basic Science, the New Zealand Science : *Infants to Standard Four and the* Physical Science, *to name a few, have* recognized the need to develop scientific attitudes.

What are scientific attitudes?

Scientific attitudes can be regarded as a complex of "values and norms which is held to be binding on the man of science. The norms are expressed in the forms of prescriptions, proscriptions, preferences and permissions. They are legitimatized in terms of institutional values" (Barnes and Dolby, 1970:3). The norms and values are supposed to be internalised by the scientist and thereafter they fashion his/her scientific practice.

The current set of scientific attitudes of objectivity, open-mindedness, unbiassedness, curiosity, suspended judgement, critical mindedness, and rationality has evolved from a systematic identification of scientific norms and values. The earliest papers of any importance in the field of scientific attitudes are those of R.K. Merton (1957). He conceptualized the norms or institutional imperatives on the basis of evidence taken mainly from statements by scientists about science and their scientific activity. He then identified four norms. These are universalism, communality, disinterestedness and organized skepticism.

Universalism requires that information presented to the scientific community be assessed independently of the character of the scientist who presents the information. The norm of **communality** requires that scientific knowledge be held in common, in other words, the researcher is expected to share his findings with other scientists freely and without favour. The norm of **disinterestedness** requires scientists to pursue scientific knowledge without considering their career or their reputation. Scientists are exhorted by the norm of **organized skepticism** never to take results on trust. They are expected to be consistently critical of knowledge.

To this list of institutional imperatives Barber (1962: 122-142) later added two more — rationality and emotional neutrality. **Rationality** relates essentially to having faith in reason and depending on empirical tests rather than on tradition when substantiating hypotheses. Scientists are encouraged also to conform to the norm of **emotional neutrality** i.e. to avoid emotional involvement which may colour their judgement.

These idealistic institutional imperatives or their resulting variants have been adopted by school science. It is argued (Ben-David, 1975:21) that abiding by the Mertonian norms helps in checking emotions and prejudices from marring one's research work. Science is also seen to be socially neutral (King, 1971) and consequently much of the endeavour of the scientific community is protected from social criticism. Price (1963) remarks that the scientific community believes that the success of science and technology can to a large extent be attributed to the adherence to the Mertonian norms. Moreover, the general public attributes much of the success of science to the belief that the scientific community must be open, neutral, self-critical, rational, etc.

But is it an unquestionable fact that scientific attitudes have been important in the success of the scientific community? Can one accept without exception that open-mindedness, disinterestedness, objectivity etc. are actually inherent or acquired qualities prevalent amongst the members of any scientific community? Is it not possible that these scientific attitudes have been popularised and then reified as a set of ideal attitudes but in reality is not often found in actual scientific practices? The following studies raise serious doubts about the scientists' adherence to institutional imperatives.

Price (1963) reveals that science is now controlled, financed and directed by the state and by industry. Ellis (1969) points out that governmental and industrial support has grown so much that traditional norms are no longer applicable. Science is now "Big Science" and scientists must conform to a new set of rules dictated to a large degree by state policies and industrial priorities. Under such a situation, secrecy and competition take on a more dominant role. External pressures of industrial demands in terms of costs and benefits and other political and economic implications contribute towards a shift in the scientific comunity's attitudes towards their work (see Rose and Rose, 1971). So bureaucratization and industrialisation of science are external factors that have somewhat diluted the scientist's adherence to Mertonian norms.

The study of the personal characteristics of scientists has also raised questions about whether the flourishing of science can be entirely attributed to the scientists' unequivocal acceptance of the traditional norms. Holton and Roller (1958) have found that the actual human characteristics exhibited by scientists are quite distant from the attitudes ascribed to scientists.

Anne Roe (1961) reports that personal factors inevitably enter into scientific activity. They influence a scientist's choice of what observations to make; they influence a scientist's selective perception when making the observations. They also influence their judgements about when there is sufficient evidence to be conclusive and considerations as to whether discrepancies between experimental and theoretical data are important or unimportant to their pet theories.

Mitroff 's study (1974) of the behaviours of Apollo moon scientists shows that scientists are passionate, irrational and strongly committed to their own favoured theories. What this means is that subjective characteristics of the scientists act as norms rather than the widely accepted Mertonian norms.

Mitroff (1974) also noted that scientists are seldom objective; there is no such thing as the disinterested observer. As Mitroff sees it, the real process of doing science is much more complicated. It is filled with subjective and even irrational elements that have been generally unacknowledged. Mitroff concludes by suggesting that "to remove commitment and even bias may be to remove one of the strongest sustaining force for both the discovery of scientific ideas and for their subsequent testing." (Mitroff, 1973: 765).

Quite often school science implies or depicts scientists as being rational and critical in their scientific activities. This, however, may not always be the case. Gauld (1973) admits that rationality does play a part in scientific activity but is not always evident and not always practised by all the members of a scientific community. Kirkut (1960) suggested that rational thinking is certainly exercised in judging the products of these with whom one disagrees although the same case may not be lavished on the arguments of scientists whose views are closer to one's own. Writings by Kuhn (1962) also provide an insight into factors and personal characteristics that influence a scientist's activity.

The degree of resistance, stubbornness,jealousy and rigid commitment witnessed among the members of the scientific community further undermines the total acceptance of scientific attitudes. Bernard Barber's (1961) study provides ample evidence of this. For example, he cites Max Planck who had recorded the following complaints concerning the practice of the members of his scientific community.

> "I found no interest, let alone approval, even among the very physicists who were very closely connected with the topic. Helmholtz probably did not read my paper at all. Kirchhoff expressly disapproved ... I did not succeed in reaching Clausius ... I carried on a correspondence with Carl Neumann, of Liepzig, but it remained totally fruitless" (as cited by Barber, 1961, Page 596).

Barber (1961) presents several examples that reveal the extent of scientists' stubbornness and resistance to refutation of established scientific ideas and to the presentation of counter-arguments and new concepts. Such investigations weaken the argument that scientists are generally openminded, objective, skeptical, disinterested, rational and neutral.

Effect on Students

Science textbooks, in their rush to present organised descriptions of structure, function and process, sacrifice human drama and personal characteristics of the members of the scientific community. Much of the textbooks' interpretation of the images of scientists and their attitudes is a consequence of the analysis and acceptance of the end-products of science. This approach has resulted in the acceptance of a stereotyped image of the scientist.

Ahlgren and Walberg (1973) and Randall (1979) in separate studies, have pointed out that students perceive scientists as cold, impersonal data-dealers, and their work as dull, monotonous and tedious. Bereft of common human feelings and compassion, the robot-type images — a consequence of the projection into the common scientific attitudes — has resulted in the promotion of a negative attitude forwards science and a gradual loss of interest in science (see Shallis and Hills, 1975).

The quality of objectivity in science seems firmly upheld by scientists and non-scientists alike. Consequently, according to Shallis and Hills (1975), those that are attracted to science subscribe to the notion of objectivity, thereby perpetuating the myth. It is of concern to the general public to realise that many of those attracted to science will be adhering to this norm of objectivity. In doing so, there is always the possiblity that future scientists would become more cold, objective and almost robot-like. However, at a time when the impact of science and technology on the society is so critical, there is a need for the scientific community to be more human and compassionate.

Science, because it appears so cold, loses its appeal for the general public. This is unfortunate especially when the general public needs to be more alert towards scientific activities. As for South Pacific students, the study of science in most cases is seen as a convenient means of acquiring a pass in public examinations. It is doubtful whether the majority of the school leavers continue to maintain interest in science. Indeed, it is increasingly unlikely that they are keen enough to develop their scientific knowledge after completing their formal education.

Conclusion

While it is desirable that students of science should be encouraged to develop these attitudes we need also make them aware of the role that personal characteristics play in the acquisition of scientific knowledge. By revealing the role of personal characteristcs that scientists are normal human beings, fallible, stubborn, emotional and irrational, we can humanise science and thereby develop in the student proper appreciation of science.

To do this the student should be given the opportunity to perceive scientists as normal, actively and occasionally fallible human beings, who are different only in the area of their special training. Students should have access to literature that reveals the extent to which the subjective side of the scientist influences his or her work.

Needless to say, classroom teachers must play the major role in this enterprise, and thus help students acquire a better understanding of science and scientists. To be effective, teachers may need to familiarise themselves with current writings dealing with the nature of scientific knowledge and the practice of scientists at work.

REFERENCES

Ahlgren, A & Walberg, H.J. — Changing attitudes towards science among adolescents. **Nature**, Sept. 28 1973, **245**, 187-190.

Barber, B. — Resistance by scientists to scientific discovery.

Science 1961, 134, 596-602.

Barber, B. — **Science and social order.** New York: Collier Books, 1962

Barnes, S.B. & Dolby, R.G.A. — The scientific ethos: a deviant viewpoint. **European Journal of Sociology**, 1970, II, 3-25.

Ben-David, J. — On the traditional morality of science. **Newsletter 13 The Harvard Program on Public Conceptions of Science**, 1975, pp.24-36.

Ellis, N.D. — The occupation of science. **Technology & Society**, July 1969, 5(1), 33-41.

Gauld, C.F. — Science, Scientists and "scientific attitudes" **The Australian Science Teachers Journal**, 1973, **19**, 25-32.

Holton, G. & Roller, D. — **Foundations of Modern Physical Science** Reading, Mass: Addison-Wesley, 1958, Chapters 13, 14 & 15

Kerkut, G.A. — **Implications of Evolution** New York : Pergamon, 1960

King, M.D. — Reason, tradition and the progressiveness of science. **History and Theory**, 1971, **10**, 3-32.

Kuhn, T.S. — **The Structure of Scientific Revolutions** Chicago: The University of Chicago Press, 1962.

Merton, R.K. — **Social Theory and Social Structure** Glencoe, I11: Free Press, 1957, Chapter 16.

Mitroff, I.I. — "The disinterested scientist", Fact or fiction? **Science Education**, 1973, 37, 761-765.

Mitroff, I.I. — **The Subjective Side of Science: A Philosophical Inquiry into the Psychology of the Apollo Moon Scientists** Amsterdam: Elsevier, 1974.

Price, D.J. — **Little Science, Big Science** New York: Columbia University Press, 1963.

Randall, A.F. — Scientific writing beyond the textbook. **The Science Teacher**, May 1979, 46(5), 18-21.

Roe, A. — The psychology of the Scientist. **Science**, August 1961, 134, 456-459.

Roe, S & Rose, H — The myth of the neutrality of science **Impact of Science on Society** 1971, XXI (2), 137-149.

Shallis, M & Hills, P. — Young people's image of the scientist **Impact of Science on Society** October-December 1975, 25(4), 275-278.