DOCUMENT RESUME

ED 125 901 SE 020 895

AUTHOR Washton, Nathan S.
TITLE Teaching the Impact of Science on World Technology.
PUB DATE Apr 76
NOTE 14p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (49th, San Francisco, California, April 23-25, 1976)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS Curriculum; Futures (of Society); Philosophy; *Science Education; *Sciences; Scientific Enterprise; Scientific Research; *Social Problems; Technological Advancement; *Technology

ABSTRACT

The role of science in bettering society is discussed, especially in relation to technical advancement and world politics. Science education is discussed as a means for preparing citizens for consumer decisions and teaching ethical values and judgments pertaining to society. (MH)

TEACHING THE IMPACT OF SCIENCE ON WORLD TECHNOLOGY*

Nathan S. Washton+

About thirty years ago, a leading professor of astronomy was very much in demand as a lecturer. His topic, "The Day the World Would Come to an End," was most popular and his regular fee for this lecture was $500. One day a civic group invited him to give his lecture but they were willing to pay only half of his fee. During the lecture, the professor described the effects of radio-active wastes, hydrogen ions exploding and melting space vehicles and other objects in space. People suddenly found themselves walking in a dense, hot liquid. At this point the professor announced, " Thank you very much for your kind attention," and sat down. The person in charge of the civic group asked the professor to please continue to forecast the events that will make the world come to an end. The professor replied, "you gave me half of my fee, so I give you half of my lecture."

FORECASTS AND DECISION MAKING

It is most interesting to observe how human behavior demands forecasts or predictions, especially where personal and public welfare

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* Presented as The First Vaden Miles Memorial Lecture at the annual meeting of the National Association for Research in Science Teaching on April 25, 1976 in San Francisco, California.

+ Professor and Coordinator of Science Education at Queens College of the City University of New York.

are concerned. For purposes of planning, the Federal government uses forecasts pertaining to population trends, energy and food requirements, supply and demand of manpower, use of natural resources, economic growth and development. Many institutions and agencies thrive because of scientific predictions and technological forecasts and are dependent upon the success with which a small number of variables are modified by intuitive judgments. At present, no adequate theory has been proposed which provides us with all of the conditions for technological change. How accurate are projections based on data obtained in 1969 to make in 1976 a forecast for the year 1986?

Donald Schon maintains, "...we see forecasts as tools or aids for decision rather than as assertions about the future. We must look to forecasting tools, in their present state, for insights rather than for answers, and guard against the public use of forecasts as self-fulfilling prophecies. We should seek to improve forecasting methodology by determining data requirements and improving data availability, and by developing more complete theories of the socio-economic-technical systems in which we are interested."(1) We need to test, confirm or disconfirm previous and current scientific and technological forecasts.

In teaching science one frequently hears the importance of learning science to understand the nature, behavior, and predictability of science. Students seem to think it is important to repeat or verify the experiment so that the prediction or forecast is correct. Many of us were indoctrinated with the concept that if a hypothesis can be verified and forecast, it is scientific. Unfortunately, our scientific

technology has many variables that cannot be quantified nor isolated within a given unit of time to yield accurate forecasts. Yet, the collection, observation, interpretation, and evaluation of data are essential for making predictions, not prophecies, in order that one can make intelligent decisions.

POPULATION, FOOD AND ENERGY TECHNOLOGY

One of our major goals in science education should be to enable individual citizens to make better decisions as consumers of goods, time, and services. In recent years, we were confronted with the problem of what source of energy, problems of economics of energy and international implications, conservation of energy and modification of people behavior and the possible use of newer technologies to meet future needs. Forecasts show that there are limits of natural resources; the continuous increase in the demand for energy and food requirements cannot be met at a future date as long as there remains a geometric progression in world population. The 4 billion mark was passed in our world population in 1975. Yet the United Nations forecasts that by the end of the year 2000, the world population will be 7.5 billion based on the birth and mortality rate. The United Nations estimates for every one death there is 1.9 births. This means that in 35 years, the population will double again. Can this geometric progression of world population be sustained on this planet? What are the economic and political consequences of continued world population increases? What are the important implications for world politics and for levels of living?

Lester R. Brown reports, "In a world of food scarcity, where there may not be enough food to go around, North America must decide who gets how much food and on what terms." (2) During 1970, there were 56 million tons of grain exported from North America compared with nearly 100 million tons during fiscal year of 1975. The U. S. and Canada exported enough grain to feed 600 million people of India. Since more than half of man's food energy supply is provided by grains when consumed directly, the aggregate of all grains serves as a food trend indicator. In 1970, the U. S. had 89 days of reserves of world grain consumption compared with 105 days of reserves in 1961. In 1972, 1974 and estimated for 1976, the decline of reserves as days of world grain consumption are 69, 33, 31 respectively. The relentless population growth, a rising affluence, and a sudden demand for food throughout the world make for insecurity and instability. North America is supplying almost the entire world with grain.

SOCIO-ECONOMIC AND POLITICAL IMPLICATIONS

Brown states, "The high costs of this food price instability are economic, political and social." (3) Hence, the teaching and learning of science need to be re-evaluated in terms of intelligent, citizen decision making that take into account the economics, political and social implications of science and technology. In teaching science for survival, it is no longer sufficient to teach nutrition based solely on crop production, plant reproduction, chemical fertilizers, pesticides

versus biological control of organisms. Some will favor interdisciplinary courses and programs; others will devise new systems of teaching science and its socio-economic and political impact on man throughout all nations.

Opposing the notion that scientists form a privileged caste, Eugene P. Wigner (Noble Prize in physics, 1963) writes: "Their social and political obligations are the same as those of other citizens. Only when they are better informed on some question than most of their fellow citizens do they have the 'special' obligation, and the privilege, to convey information to their fellow men." (4) He also emphasizes that scientists should not want to dictate the wishes of other peoples. Alfred Kastler (Nobel Prize in physics 1966) stated that the scientists's responsibility should inform the public when discoveries might lead to detrimental effects and, at the same time, objectivity and the avoidance of whipping up passions should be maintained. Will scientists join with economists and political scientists to advise and forecast the future implications of the need for food supply for many nations from North America? With the exception of Western Europe all geographic areas were net exporters prior to World War II. Today the picture is very different. More and more countries are importing more food supplies than they can produce. How much longer can North America continue to feed the world? More than half of their grain supply are now imported by Belgium, Japan, Lebanon, Libya, Saudi Arabia, Switzerland and Venezuela. It should be noted that in recent years on several occasions, due to political pressure, exports of grain were limited to the Soviet Union and to Poland as recently as in the late summer of 1975. And in many countries the negative effects of ecological abuse such as deforestation,

overgrazing, desert encroachment, flooding and soil erosion have added to the complex economic problems of the 1970's. Predictions are that scarcity of food supply will persist and only sporadic surpluses will appear locally for short periods of time. It also appears that dependence on North America for grain will continue to increase.

On February 20, 1976 SCIENCE magazine devoted its entire issue to materials and energy. Abelson and Hammond write: "Renewable resources are crucial to an enduring civilization. The articles herein dealing with this topic leave the impression that this nation has not yet got its priorities straight. Indeed, materials of all kinds are so basic to the continuance of our society that the country would be well served by increased attention and - more to the point - some constructive action to insure a continued supply." (5)

TECHNOLOGY AND INTERNATIONAL IMPACT

The technology of extracting essential metals such as aluminium from their ores may serve as an illustration which can affect a national or perhaps an international economy. From the middle of the 1800's to the beginning of this century the price of extracting a pound of aluminium changed from over $500 to mere pennies per pound after the Hall process was discovered. The uses of aluminium in manufacturing materials for housing, small and large electrical appliances and vehicles for transportation such as airplanes are vital for a growing economy. The shortages of a critical material such as the aluminium ore, bauxite, were noted in the early period of World War II, when Hitler had to

conquer The Ruhrland and other areas to obtain bauxite so that aluminium would be available to manufacture aircraft. The teaching of the extraction of aluminium from its ore and its uses in society are inadequate for citizen decision making that affect political and economic survival. The critical shortages and their impact on military, political and economic needs may determine the nature of international relations. How will scientific literacy as it is understood in the schools and colleges today help citizens to intelligent decision making? What is the relationship of scientific personnel to legislators and government leaders?

INTERNATIONAL MEANINGS OF SCIENCE

During the past three years I met with many scientists and science educators from various nations and I asked them to express their meaning of science and how its technology affects the people in their nation. Edgar W. Jenkins of England states, "Science is what scientists do!" He is concerned with the fact that little is known of the ways in which society produces and responds to science and technology. Ethical issues will continue to be raised until more resources are devoted to the understanding of the interaction - between society and science-technology. Jenkins maintains that science and technology are among the most potent, if not the most potent agencies involved in social change. He also indicates that today we are more suspicious and even frightened of technology as compared with the recent past.

Throughout the various interviews, discussions and correspondence

with scientists and science educators, I noted in almost all instances the need for a greater emphasis on technology in our science courses. R. P. Tisher of Australia suggests that science probably most affects people in his nation through its material and technological aspects. He also believes that there should be a greater awareness of benefits, limitations, and dangerous aspects of technological advance. To him, science is an exciting, creative endeavour by man in providing explanations and interpretations of the world. The aim, according to Tisher, is to give man the ability to predict and to use, develop and conserve natural resources with a degree of moral responsibility and good judgment. The need for change, modification and flexibility is noted among many of the scientists. Hideo Ohashi, Director of the Science Education Research Center in Japan stated that scientific explanations are a creative endeavour of men and they are probabilistic and by no means perfect. Technological progress occurs from such creative endeavour and adds to the material prosperity of a nation.

To Ohashi, science is a body of knowledge about the nature and methods of acquiring such knowledge or inquiry. In recent years, there has been a closer relationship between science and technology. He finds that there is a shorter time gap between scientific discoveries and their application to the development of technology.

Several Japanese scientists said that science and technology have improved the standard of living in Japan; there is no deeper understanding of the influence of science and technology on the human mind. During interviews with the speaker, the words "scientific" or "non-scientific" were frequently used in discussion for advocating or

opposing given proposals. This is a superficial respect for science and is an indication of its misuse of the word, science as authority.

Two extreme viewpoints of science were expressed: (1) Those who believed that science was absolute, almighty without any limitation, applicable to every matter and denying everything which could not be explained by science and (2) those who are "allergic to science." The few people who try to be scientific in thinking and conduct themselves accordingly in their professional or vocational activities do not behave the same in their relaxed homelife situation. They live a dual life in and outside the home.

Science is training people to predict the future according to Yujiro Nakajima, chief supervisor for science in Tokyo.

SCIENCE FOR GOOD OR EVIL

Other scientists referred to science as a way of life which is universal. Throughout the world, scientists stated that people are affected by science and that science is international. They insisted that science belongs to all people and can be used to destroy the prejudices and help unify mankind. Although the average Japanese citizen reads about science and its technology in the daily newspaper, he is still afraid of science. Problems such as pollution and nuclear energy confronting Japan have created a real awareness of science in the people.

The continued fear and concern of science was mentioned by many science educators. They said that "science inquires into questionable matters of nature" and was attractive to them but "on the

other hand, it seems to be a demon which makes mankind walk the way to catastrophe."

Young people in Japan are approaching the meaning of science with much caution. Even though they list the economic and health benefits to mankind, it was interesting to hear a man 24 years of age in Hiroshima saying: "Science has grown a monster without his yoke called philosophy."

Tamir of Israel states: "Science helps man understand his environment and the phenomena around him; it provides logical means and efficient methods for finding explanations to these phenomena and for solving problems." He believes that science is respected by most people in Israel since it helps develop the technologies which contribute to the improvement of living conditions and ensure the security of the country.

Israeli scientists stated only the positive effects of science and technology in terms of economic, cultural, health and military security. The Japanese scientists on the other hand, cautioned people about the dangers of scientific technology.

Bronowski proposes the Principle of Uncertainty in which he claims that all knowledge is limited. He writes: "There is no absolute knowledge. And those who claim it, whether they are scientists or dogmatists, open the door to tragedy." (6) He discusses the dangers of absolutism in science as a major factor in having produced a Nazi Germany under Hitler - a principle of monstrous certainty. This type of conviction is based on dogma, ignorance and arrogance.

Under the influence of strong passions, scientists also misapply or misuse knowledge according to Sarton. He writes: "In any case, it must not be arrogant, nor aggressive, for it is like all other things

human, essentially imperfect...Everything which we think or do is relative to man. Science is nothing but the reflection of nature in a human mirror. We may improve the mirror indefinitely; and though we may rid it, or ourselves, of one cause of error after another, it is and will always be, for good or for evil, irremediably human." (7)

THE SCIENTIST AS A CITIZEN

In recent years, many scientists throughout the world have spoken up forcefully on many major social issues. In an interview with the Nobel Prize winner in physiology in 1937, Albert Szent-Gyorgyi says that he cannot isolate himself from human problems and he tries to bring peace and human understanding closer together.

Scientists are participating as citizens by not only advising political leaders but also by actively engaging in discussions to influence citizens voting on many social issues. Solly Zuckerman who was chief scientific adviser to the British government until 1971 writes on the mutual tolerance that should prevail between scientists and politicians. From his experiences, politicians are usually more sympathetic and show greater respect to claims made by scientists. The scientists do not show the equivalent degree of understanding about political problems according to Zuckerman.

TEACHING SCIENCE FOR TECHNOLOGY

Finally, teaching the impact of science on world technology requires a humanistic scientific approach and serious consideration should be given to ethical values and judgments. The learner needs to recognize his attitudes and emotions as he relates to the applications of science and to society and to himself. Science is no longer impersonal. In teaching science, we should ask ourselves what are the consequences of applying scientific knowledge or research. Have we exhausted the understanding of various alternatives? Can we emphasize the learning of what we don't know in science to stimulate further research and development? How do people learn that scientific research is dynamic and that the most prevalent constant in science is change? With rapid changes in world technology our curricula need to be modified to include humanistic and objective bases for intelligent decision making in solving problems of food, energy and population. Along with curricula changes that include technology, the personal interaction between learner and teacher, scientist and politician, citizens and their intelligent behavior with other societies are necessary if what we teach is to produce effective survival on this planet.

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