28 May 1971, Volume 172, Number 3986 **SCIENCE**

One Objective for Science Teaching

Since coming to Washington and seeing at firsthand some of the problems of matching science to society, I have become concerned that public expectations of spectacular achievements are far greater than science and technology can produce. I see in the newspapers and hear from many of my lay friends that, if we can accomplish successfully the Apollo missions, we should be able to clean up the environment, provide adequate mass transportation, increase the availability of health care, and so on. Logically, such statements are non sequiturs, and yet they do have a certain amount of popular appeal. As a result of the remarkable accomplishments of science and technology there has arisen a general feeling that scientists and engineers can accomplish anything when they put their minds to it. Going to the moon seems, superficially at least, far more difficult and certainly more exotic than maintaining the biological oxygen demand at a reasonable level in the Potomac River.

Science and engineering are not omnipotent. There are several reasons why this is so. First, technology cannot violate the laws of nature. For example, we cannot build a perpetual motion machine because the first law of thermodynamics would be violated.

Second, a different constraint on science and technology is the so-called state-of-the-art. Deriving electric power from nuclear fusion sources would violate no law of nature, but such an achievement is beyond the state-of-the-art at the present time. Man can tailor the world to his liking only to a partial degree. Only certain pathways are open. Man and his society can pick only the best of those available, and none may be entirely palatable to all segments of society.

A third limitation on science and technology arises from economic, political, and legal constraints. It is generally conceded that satellite systems on the domestic scene would be useful and might solve important problems in communications. However, the country does not have domestic communication satellites, principally because the associated sociopolitical problems have not been solved.

Thus, science is constrained by the laws of nature, by the state-of-the-art at any given time, and by the structures of our society and our legal system. This deceptively simple statement is too often ignored by the public. In my view, the most important objective of science education is to make future generations aware of the real nature of the scientific and technological enterprise in just this sense.

What principles do we have which can accomplish this educational objective for science education? I believe that these subtleties can only be communicated through an experience with reality. This is a familiar viewpoint in teaching physics and chemistry where experimentation has long been an essential part of courses. One possible approach is to make available to the general student firsthand experience with a digital computer. A general purpose computer can theoretically solve any problem that is, in the language of automata theory, computable. Thus, the ambitions that the student may develop, or indeed that society may develop, for computer applications are essentially unlimited. However, before any one application can be brought to fruition, it must be reduced to a sequence of explicit steps that form the computer program. It is the discipline of reducing desires and ambitions to explicit operations that is missing in the lay concept of science and technology. The digital computer could be used for communicating that idea to the general student. Few experiences are as educational as finding that one's ideas must be made concrete lest they become ephemeral.—EDWARD E. DAVID, JR.

Dr. David is science adviser to President Nixon. This editorial is adapted from a talk given on 27 March 1971 at the 19th annual convention of the National Science Teachers Association during a symposium on the national assessment of educational progress.