"Some type of multidisciplinary approach is required for the analysis of technology and of its effects on society."

Technology and Society

by

Prof. Antti J. Niemi

From our professional experience and private life we know that technology and society are connected with each other in many ways. It is not only the large networks for communication and traffic which bring all members of the societies, both nationally and internationally, into contact with one another, but also the industry which, through its products, makes the technology contribute to everyone's life. But it is not sufficient that these commodities are made available, they have to reach the acceptance of the consumers as well, in order that they may be produced economically in large quantities. And the society can also have a more active role, when it, for instance, asks for technological solutions of its problems of transportation, energy and protection of environment.

It is characteristic of technology to continuously generate new products and propose a spectra of alternative solutions which may be similar to existing ones, but which often exhibit novel, unexpected features and may sometimes satisfy such needs which were not even recognized previously. Thus, the technology can be considered a means for society to reach its prescribed salient goals; moreover, it certainly has an independent value of its own represented by the creation of such new devices, methods and systems which were not anticipated by the society. This unsolicited invention and materialization of novel constructions are essential contributions of technology to human culture which is comparable with the artistic creation or the discovery and demonstration of new facts and theories in science.

Already the earliest inventions were a decisive factor for the formation and operation of human societies. The simple mechanical hand tools paved the way for the specialization of men in various crafts. This specialization enhanced the skills of the craftsmen making them need the services of one another, leading to a society which was based on division of work among its members.

Science was not involved in the early development of technology which represented simple mechanics or was based on such other natural phenomena which were observable by the human senses. It was not until the 19th century, when scientifically observed facts found use in technology. It is, however, incorrect to consider the technology of yesterday or today as a direct result of scientific studies. A technological creation always requires inventiveness; this produces the technical idea which determines how to make use of available scientific facts.

Despite its novel features, a particular step of the technological development can be set to a rational relationship with prior technology. This is illustrated for example, by the gradual harnessing of the various sources and forms of energy to the service of man. Thus,before the introduction of the steam energy, water power and wind were used and, still earlier, the muscle power of a domestic animal for mechanical work, and thermal energy for other processing. Afterwards electric power and nuclear power were utilized. All these developments contributed to the liberation of man from the use of his muscle power as the primary source of energy. He became more and more in control of the other forms of energy, so that less human effort was required for the production of a unit commodity.

This substitution of man as the source of mechanical power with other forms of energy and the widespread use of the new developments have had effects which changed radically his living habits. Since an increasing amount of useful commodities has been produced with less effort, working time has correspondingly been shortened and work has become considerably lighter. More goods and services have been made available to man to help him in his work and to bring him more conveniences and comforts during his increased free time. New institutions have been established to represent the labor market parties which negotiate on the division of the acquired benefits between the employers and employees, and no major decisions which affect the economic life can be made today by the political governments without consultations with these organizations.

Often the technical and economic benefit derived from utilizing a new technological method has been foreseeable, and pretty soon, its use in the industry gains popular acceptance. On the other hand, its introduction may have had quite unexpected effects on the society. Some social change is, therefore, indicated to correspond to the technological innovation, but since the society has more inertia, difficulties have often appeared during the transient period before a new balance can be achieved. Thus the term "industrial revolution" is more applicable to the social effects of a technological change, like those of the introduction of the steam power, steam engine, and machinery powered by it, than to the primary change itself which certainly is a great step toward technological development.

Although new technical devices have been already introduced, earlier methods are not necessarily totally discarded; they have remained in use in applications which are more suitable for them. In other cases, new procedures may have been developed as augmentations of earlier ones, consisting of both traditional and novel parts in combination. This also shows that the technology as such is more evolutionary than revolutionary. For instance, newer sources and forms of energy have not rendered obsolete and unnecessary the use of the steam, water, wind or the human muscle power.

The computerization which is presently in progress consists only for a small part of a substitution of the earlier technology, and mainly of the transfer of human routine brain work to the electronic computer. The computerization, together with the automation of production processes, can also be considered a logical step after mechanization which substituted man's mechanical operations by the machine and his muscle power by the various other power sources, but which left the computational, decision-making and control operations still to man. The computerization and automation have greatly increased the efficiency of the business industry; both have made man the supervisor of automatic devices and systems, educed the need for human work in the production of any amount of services or products, enhanced the quality of commodities, minimized the monotony of work which had often been aggravated by mechanization, and changed the nature of work and its environment in many other ways.

These developments in industry and business have large effects on the whole society. When man's role in the production of goods and services changes, new jobs requiring higher intelligence are formed, and many traditional crafts become obsolete or less needed. Since more quantity is produced with less human effort, the overall employment picture changes resulting in an increase of leisure time. New products, services and means of communication are made available which offer a wider choice of recreation to the individual, thereby changing his traditional living habits. This process has started about 30 years ago and is presently characterized by application of microprocessors and systems using them. Due to its effects on society and to the requirements it sets to society's ability to adapt, it has often been called the second industrial revolution.

Another feature which characterizes the present technology is the formation of large systems which are found today in industry, business and general administration. Based on communication networks, they assist in the control and supervision of the production processes and machinery, and in the administration and connection of the computers both with one another and with the terminals of a large number of users. It is more difficult for an

individual to comprehend the operation of such systems or even of their new components and automatic devices, than for him to understand the earlier practices. Since everyone is today brought into contact with such systems and devices, some familiarity with the principles of their operation and the corresponding need of education and instruction are required.

As far as technical education is concerned, the need for new professional skills has been generally understood, and corresponding measures have been adopted in European countries. In some technical colleges, in addition to changes in the curricula, faculties and polytechnics, and professional skills are updated by means of supplementary education, and programs of re-education have been established for those whose jobs have become obsolete. There is more inertia in the field of general education where the needs arising from technological development have to compete with other societal and cultural needs. Since the reforms require comparisons of technical and economic facts with only qualitatively appraisable, abstract values, they have materialized differently in different countries and have generally proceeded more slowly than those in special education.

Although the understanding of technology is increased and its adoption made easier through an appropriate education, there are also other factors which influence the attitudes of the laymen towards technology. After the economic problems entailed in attaining a sufficient standard of living have been largely removed, various other needs have gained importance which the technology has to satisfy or not violate. Thus, such factors as the conservation of nature, prevention of environmental pollution, occupational and general safety, sufficient degree of employment and integrity of private life are today emphasized in public discussions.

The importance of these factors are variable, and individual opinions are often strongly expressed in connection with such contemplated large systems requiring decisions by the public administration or political representatives. Since such solutions cannot be found which would satisfy all individuals and groups of the society and correspond to the requirements of the industry and healthy economy, the politicians are often reluctant to make needed decisions. Therefore the decisions are delayed, and after they have been reached, the technologists who have to carry them out are criticized by those groups whose demands are not met.

Technology is associated with the creation and production of material goods which benefit a community. Such community has traditionally consisted of the producer and the users of a product, but today most designers and manufacturers also tend to take into account those who are affected by the production or use of the product. Correspondingly, the overall benefits should be understood to cover all direct and indirect benefits and disadvantages as far as they are known and can be evaluated.

However, since the indirect effects and the size of the affected community cannot be determined accurately, the ideas of other concerned individuals about them may differ from those of the producer and the users. Unfavourable attitudes towards a certain technological development may result, if some individuals would find its overall benefits to be negative.

Man's interaction with nature is often subject to differing appraisals. Such interaction is required for the extraction of raw materials which are used for the production of goods. Usually wastes are formed which cannot be processed without incurring undue cost. Although much effort has been devoted to the transfer of non-renewable resources to renewable ones, and to the development of low-waste production and wastes re-cycling, the interaction of the technological production with nature and environment cannot be totally eliminated. Discrepancies will, therefore, appear also in the future between the industry and various individuals and groups of society, as long as differences of opinion exist on the extent of the interaction.

The question of man's right to dominate and exploit nature and also the degree and method of exploitation has interested philosophers. Man's unique intelligence not only

endows him with certain rights but also sets limitations. It is considered that man's final goal is not the material domination of the nature, but the support of human existence and human spirit. This spirit is present in technology, in the form of intellectual creation, i.e., the invention and design, and the domination of the matter is essential in the concretization of the ideas.

Fears are sometimes expressed of an insufficient control of technology by society. Sufficient control is enforced when society uses technology as a means for achieving defined goals; however, the control of the independent development of the technology is more problematic. A control is certainly justified, if a device or system implies hazards to the individual or the society. Therefore, official and unofficial regulations and practices are accordingly established for their protection.

On the other hand, essential limitations should not and in fact, cannot be set to the human spirit which produces the innovative ideas, in the same way that they are not imposed on other forms of cultural creation. Instead, they should always have a freedom of materialization in an appropriate extent, so that a proper picture can be formed of their practical, both beneficial and unfavourable uses and effects.

Technology influences society most directly through the development and distribution of industrially produced consumer goods which are made available to everyone in the market. They are sometimes said to represent a diffuse technology, since their consumption is random and does not follow a deliberate plan. Anyone may, at least in principle, choose freely, to acquire such product, but once acquired, its use may change his customary behavior in some respects. If such changes take place more generally in the society, changes in more abstract cultural values may result. Due to the availability of such goods on the market and the free choice of the individual, considerate changes may thus take place in the society through relatively smoothly proceeding processes.

A development in the specific technology of a branch of industry affects directly only those employees whose work would be subject to change. The effects of the development in one plant on employment, attitudes of the employees, etc., are quite limited, but they become more extensive, if the same change is made in many plants of the same branch, and if comparable changes would take place in other industries. However, since the technological development depends on the branch and on the type of applied technology, it should be studied separately. Questions such as what are these changes, what are the effects in individual branches and industries, and how do they contribute to the overall trends should be asked.

A study of the economic, social, psychological and other effects of the technological development should analyze, in addition to the effects, the basic technological change. Thus, such study should be multi-disciplinary and should apply both appropriate technological and non-technological approaches. This implies the execution of such studies by multidisciplinary research teams.

So far, technologists are mainly interested only in the technological development, while other scientists, in the effects corresponding to their specializations. Considering an objective approach to the effects of technology, the studies are unsatisfactory, if the technologists do not study the effects and if the non-technologists study only effects and not the causes. One may infer that the effects at one side and the technology at the other side do not receive due attention, and in such cases misleading conclusions may result.

If the effects of technology are studied by a multidisciplinary team which consists of technologists and other professionals, and which pursues scientific extraction of new knowledge, more objective results can be obtained. It may also be expected that the understanding of the technology as well as of the effects will then be increased, and the degree of importance given to the various causes and effects by the different specialists may be brought closer to each other.

Since studies on the effects of technology also interest other scientists, the technologists should also be encouraged to take part in such studies, in order to improve and check on the technological accuracy of the results. Some incentives are needed, because the technologists have normally been rather reluctant to participate.

Some multidisciplinary studies made so far revealed that new, deeper knowledge of the technological and non-technological effects and of their dependences on the technological causes is obtained by using such approach. The results of the studies and their unbiased nature have contributed to increased understanding and acceptance of the technology. It seems obvious that the citizens of the modern industrial society are getting mature enough to receive accurate information on both technological development and its various effects, independently of what these may mean to them and to the other parties of the society.

Multidisciplinary approach was a central theme of a recent seminar of the Society Commission of FEANI in which the relationships of technology with society and culture were discussed. Similar subjects have been reviewed at some meetings organized by UNESCO in which the formation of an international, multidisciplinary or interdisciplinary body has been suggested for the study of the consequences of the technological progress. Because of the basic role of technology, it would be important that technologists are represented in such bodies, even if they have not been too active in their fields.

The scientific approach cannot be applied to the study of such technological changes which have not yet taken place. On the other hand, a knowledge of the possible effects of a new or not yet fully developed technology would be very important to the industrial enterprise or social body which has to decide on its materialization, and all positive and negative effects and requirements of such technology should be considered by the decision-makers. Moreover, some type of multidisciplinary approach is required for the analysis of the future technology and of its effects of various kinds on society.

The technology assessment method has been developed for such multidisciplinary analysis. Such study may be made e.g., for an industrial enterprise, when the technological and economic consequences of the introduction of alternative technological methods and solutions are of primary interest. If for example, a body of the general administration initiates a study, the effects on the society, environment etc. are usually the main concern.

Such studies may be highly interesting to various political and other groups, and since they have to be unbiased and impartial, they must be made independently of such groups and be protected from possible pressures. In the United States where technology assessment studies are governmentally organized, this is conducted in the Office of Technology Assessment through the supervision and control of the Congress. This office performs the analyses, but an advisory panel consisting of representatives of all interested and potentially affected parties is also consulted. These representatives may in effect be able to see if their concerns and interests are included in the studies. However, the task of conducting the study itself is performed independently by the Office.

It is in the essence of the technology that leads to material benefits for the society. As engineers, we can observe these benefits easily, but our views are biased due to our educational and professional backgrounds. People of other backgrounds see the benefits differently, and observe more often also threats which we cannot deny. Thus the knowledge of the various effects of the technological development and of the strength of these effects is presently uncertain and imperfectly studied, but some gross phenomena are known to be in progress.

We know that technology provides us with more free time, easier means of communication and traffic, easier access to better, more convenient goods, services and other benefits. It also makes the industrial work more efficient, safer, cleaner, lighter and more challenging to the human intelligence. We should invite other professionals to get familiar with

the basic, innovative process of technological development which generates these beneficial devices and systems, and simultaneously, through cooperative studies with them, increase and check the information of its various effects.

Technological development is a continuous process which keeps the society in a state of change and brings about difficulties of adaption. With our knowledge and experience of technology, we may contribute to a better understanding of such social processes which have technological causes and thus reach the attainment of a smoother social change. We should have a double interest in such understanding, because we, in addition to being technologists, are also members of the society. Consequently, our position is critical in the establishment and maintenance of a fruitful interaction between technology and society. Studies of this nature done with the cooperation of other professionals seem today highly needed.