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Modern Science as a New Knowledge System: Science Technology and Society Perspective

Dr. Didgi Harshavardhan,

ICSSR Post-Doctoral fellow, Osmania University, Hyderabad.

Abstract

In this Paper the emphasis is on the history of the relationship between the social human sciences and natural sciences throughout the modern period. It begins with the classical enlightenment and continues into new developments in the political sociology of science and technological studies. Before the 16th century, human understanding of the universe was mediated by theoretical beliefs derived from ancient Greek metaphysics and doctrinal beliefs from the Bible and the Church. The birth of modern science as a new kind of knowledge was marked by the Copernican revolution which questioned the Ptolemaic view (geocentric view) of the universe and postulated the heliocentric model of the universe. This challenged the biblical or church-centered idea of the universe.

The Copernican revolution brought in reason as a substitute to the doctrine of faith and opened an era of revolutionary shift in knowledge systems from theological knowledge to knowledge based on reason and evidence. Francis Bacon (1561-1626), an English philosopher, statesman, scientist, lawyer, author, and pioneer of the scientific method, argued that valid knowledge about the universe could be generated by employing our sense perceptions. He considered science to be not only an intellectual enterprise that yielded knowledge about nature but also as a practical undertaking to gain mastery over nature. Bacon was the first figure in the scientific revolution to draw out the full implication for the society- nature relationship of the emerging principles of the new science (Popper: 1996). His concept of science-society relationship served as the basis for the Enlightenment and its perspective on nature and society.

Thomas Hobbes (1588-1679), another pioneer political philosopher and scientist stressed the relationship of science to the state and power. He argued that modern state and modern science are intimately related to each other. The modern concept of science - society relation drew its inspiration from Baconian and Hobbesian concepts of science and society. French philosopher and mathematician Rene Descartes (1596-1650), was one of the key figures in the scientific revolution, laid the foundations for a rationalist theory of knowledge by stressing that every human being is endowed with the power of reason. These classical tried to drew relationship between science and society in the context of classical enlightenment.

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2. Sociological Studies of Science

When we look at the sociological roots of science studies, we can see that classical sociologist like August Comte, Emile Durkheim, Karl Marx, Max Weber trusted that science is an independent, objective form of knowledge fostering the development of society[1]. The serious attention to the study of scientific knowledge started only in the beginning of the 20th century. The Sociology of Knowledge perspective of Karl Mannheim (1936) looked at the different categories of ideas/thought, knowledge, and social reality. It also considered the social origin of ideas and their effects on society. He argues that all knowledge except scientific knowledge is socially, culturally conditioned. According to Mannheim the scientific knowledge stands rational, universal, objective invariant across time and contexts.

Robert Merton (1942), subscribed to Mannheim's theory of knowledge, started an endeavor of science as a social institution. He looked at the organizational and behavioral features of scientific practices. He claimed that the institution of science functions based on a set of ethos, to which all members of the scientific community are committed. The four-principal ethos's are universalism, communality, organized skepticism, and disinterestedness. Merton also sees the root of scientific development in Europe in Protestant ethics. Merton's 'institutional approach to science' criticized from different angles (Mulkay-1973, Wynne-1979). It opens a new sociological understanding of the natural science. Thomas Kuhn (1962) argued that science cannot be fully understood without relating it to history. Scientific theories must be seen in relation to the period in which they were produced. Kuhn's seminal work *"Structure of Scientific Revolutions"* gives a clear historiography of science and a comprehensible account of scientific change. The publication of the book stood as a landmark event in the history of philosophy, and sociology of scientific knowledge. Bloor (1974) argued that all knowledge including scientific knowledge is socially and culturally caused.

New progresses in the sociology of science and technology have gone further towards understanding the preparation of science and the production of scientific knowledge and technological innovations. They have used sociological and anthropological methods to understand the practice of science. The laboratory study of Science and Technology Studies has made an attempt to comprehend the process of knowledge production in its natural setting i.e. the laboratory. Latour and Woolgar (1979) in their book '*Laboratory Life: The Social Construction of Scientific Facts*' made an anthropological study of Roger Guillemin's scientific laboratory at the Salk Institute in California. (Latour, Bruno, and Steve Woolgar)

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(1979). through these laboratory studies they proved that science is not merely a descriptive activity but is also a constructed one. These micro-sociological accounts of science stress socio-cultural contexts and how they shape scientific knowledge.

The cultural turn in the study of science marks the relationship between the socio-cultural norms and the practice of science. It argues that scientific and technological developments are culturally mediated. Socio-cultural change also leads to changes in the practice and claims about the production of scientific knowledge. In other word the division between external world of science and the internal science is not opaque. According to Hess (1995) cultural turn questioned the *culture-free, transnational* concept of scientific disciplines and they argue that one scientific discipline implemented in a different cultural tradition that discipline will rework and transform according to that cultural situation. The cultural turn highlights the important of epistemic heterogeneity of natural science against epistemic homogeneity of it. (Knorr Cetina, Karin)

3. Political Sociology of the Science and Technology

Political sociology of science, as a perspective emerged in the context of a new socio-political and economic scenario. It emerged in the West in the 2nd part of the 20th century. The neo-liberal policies of the governments and the commercialization of science for the corporate need led to the development of this new field of inquiry in science technology studies. It looks at present developments in economic and political conditions and their influence on the production and the use of scientific knowledge. It also looks at the impact of these developments on the public and science activists - who struggle to make scientific knowledge more approachable to the needs of citizens. Stuart. S. Blume (1974) a British sociologist has argued that social institutions of modern science are highly political, and that science is an integral part of the modern state. To Blume ‘the social stature of modern science is extremely depended upon social, economic, and political organization of society and tremendously sensitive to changes in this environment. (Blume. S Stuart) (1974)

The political sociology of science examines the power relations and practice of power in the creation and distribution of scientific knowledge. Scott Frickel and Kelly Moore (2006) outline three key elements in the political sociology of science. First, it emphasizes the practice of the unequal distribution of resources and power. In the practice of science, power and resources are distributed according to the social and economic position of the actor. These are related to class, ethnicity, gender, caste etc. The second element of political sociology of science looks at the rules and rulemaking in scientific knowledge. It is very

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important in the practice of science because it determines the legitimacy and credibility of the finding and its acceptance in the community.

The third element is related to the organisational character of science. The present scientific landscape is controlled by different organisational imperatives. In early days it was confined to the circle of the scientific community; but at present, outside actors such as civil society organizations, NGOs, trade unions, social activists etc. have entered the field and they play vital role in the shaping and reshaping of scientific knowledge. These organizations have played very significant role in liberating science from the hands of the elite and try to make science a socially responsible social institution.

4. Science Movements and Civil Society Organizations

Science movement is a collective effort to bring about change or to resist changes in the field of science and technological innovations. This study looks at different dimensions of the science movements and their engagement with science and technology. Three modes of public engagement with science are acceptance, rejection, and coexistence. Science movements, along this line, can be divided in to three broad categories. First, pro-science movements, that concentrates on the practice of science from the perspective of the scientific community. Second, anti-science movements, which reject modern scientific knowledge and propagate traditional knowledge and practices. Third, radical science movements, those emerge from the scientific community or from civil society. They pose critical questions regarding the practice of science and contribute to changes in contemporary practices. These movements champion democratization of science and technology. They encourage public involvement in decision making in the field, insertion of popular perspectives in specialized fields and public participation in policy building and governance of science.

Science movements can be understood by using the theoretical framework of social movements. The most important theories under this framework are, a) Resource mobilization theory; b) Frame analysis and c) Political process or opportunity theory. In the context of science movements, resource mobilization theory looks at science and technology as a potential resource for the mobilization of people for the movement. Frame analysis would see science and technology as providing a framework to analyze and define the issue or the problem of science and technology. On the flip side political process or opportunity theory looks at the structural conditions like risk and hazards created by scientific and technological innovations that lead to the development of movement. These frameworks will give a broader

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canvas to analyze science movements.

Hilary Rose and Stephen Rose (1972, 1979) have discussed the development of radical science movements in Britain and the USA. They have analyzed how science and technology was incorporated into the state mechanism and how they were used for military proposes. They have documented the history of different organizations within the radical science movements and their ideological bases. Most of these movements emerged from the ideological support of the new left. They analyzed the radical science movement form first decades of the 20th century to the 1970s. These movements emerged in the context of three important characteristics of contemporary science. They are, first, the abuse of science by capitalist states for military needs and destructive proposes, second, the link between modern science and capitalist ideology and finally, the elitist management of science.

Hess (2006) examines how social movements and other form of activism affect science, technology, and industry. Through his work *'the Alternative Pathways in Science and Industry: Activism, Innovation, and the Environment in an Era of Globalization'* he offers a conceptual framework to know the relationship between science and technology, science activism in the background of globalization. He suggests a new way in where three related fields of study can be fetched together and move forward to a better understanding of the changed socio-economic and political situation. He analyses how social movements augment democratic participation in modeling scientific research field, technological innovation, and industrial change. Through this he explores the interconnection, incorporation and transformation of science and technological development and social movements. Hess (2006) studied two types of science and technological movements. They are: first, industrial opposition movements which demand for moratoria on unwanted technology and products, and second, technology and product-oriented movements which foster the development of alternative technology and products.

5. People's Science Movement in India

Post-Independence India has witnessed very rapid improvements in the areas of science and technology. The Scientific Policy Resolution of 1958 laid the foundation for growth of science and technology infrastructure. Science and technology were seen as important instruments in achieving rapid economic development and cultural transformation. But the important task of the governmental and non-governmental organizations was to create scientific awareness and scientific temper among the people. Jawaharlal Nehru, the first prime minister of independent India emphasized the impotence of inculcating scientific

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temper among the people.

Several governmental and non-governmental organizations involved in creating scientific awareness and inculcating scientific temper subsequently emerged. The National Council for Science and Technology Communication (NCSTC), Indian Science Communication Society (ISCOS) Kerala Sastra Sahitya Government (Science organisations) the science clubs in West Bengal and Orissa, the Lok Vignyan Sanghatana in Maharashtra, science groups in Tamil Nadu, experiments like Kishore Bharti in Madhya Pradesh and the Medico Friend Circle are important among them.

Krishna Kumar (1985) studied people's science movements and has pointed out two main concerns of these movements. They are: (i) the knowledge and benefits of science ought to be rightfully distributed' and (ii) individuals working in science and technology institutions must understand the problems of the poor people of the country. Science movements are a collective effort to bring change or to resist the change in the field of science and technological innovations.

In a broader sense, movements relating to science and technology can be divided into four categories.

- Movements to enhance public awareness about science by governmental agencies and science institutions. They give attention to the mainstream scientific paradigm instead of critical engagement with science.
- Anti-science movements that reject modern science and technology because it creates hazards for human beings and the environment. They are traditionalist critics of science and technological innovations.
- Movements to popularize science among the general public in a critical way. They advocate responsible science for the common good.
- Reform movement and counter movements the in scientific field, such as the Pugwash movement, technology and product-oriented movement, green chemistry movement, etc.

Zakhariah and Sooryamoorthi (1997) in their work "Science in Participatory Development: The Achievements and Dilemmas of Development Movement: the Case of Kerala" studied people's science movement in the context of its role in the participatory development. This first comprehensive study of science organizations, examine the origin and development in the unique socio-political and cultural context of Kerala. They argued that science organizations played a major role in the advancement of Kerala especially in the areas of participatory development.

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Issac and Iqbal (1988) gave a social account of the government from its formative period to late 1980s. They gave a thorough history of the science organizations from its formative period to the end of 1980s from an insider's point of view. Both two works did not deal with the post 1980 phase of the Government. This phase is very much important in the 5 decades history of government. The major development in the strategies and ideologies of the Government took place in the period.

The organizing thrusts of Science, Technology Studies (STS) is to pay devotion to the social implication of science and technology and make it more democratic by ensuring peoples participation and enhancing the ethical component of science and technology. Science movements are an important corridor to understanding the dynamics and the relationship between science and society. They pose ethical questions on the implication of scientific knowledge and technological artifacts. They also help to improve public understanding of science and technology and increase people's participation in scientific and technological decision making. Sometimes science movements can influence the making of scientific knowledge and its application in accordance with socio-political and ecological considerations.

Bernalian conceptualization of science as an important social institution and as a force of production. Science movements' activists use science and technology from a broader outlook to engage with it. They maintain that understanding science from the epistemological or methodological perspective is not enough to capture its diverse effects on society. Bernalian conceptualizations give us a wider perspective from which to view science and technology, in the framework of distortion and anti-people developments in the application of science within capitalist order.

Popular Science: An Overview

The conceptual clarification of science is very important in understanding the interrelation between sciences, society, and science movements. The meaning attached to the concept of science differs from the one group to another. The experts and technicians have an institutionalized understanding of science, which may be not same as that of public and lay people. The latter's sense of science is formed in close relation to the technological artifacts they use in everyday life. At the same time, the counter-expert will give an alternative answer to the questions posed by the experts. So, science as an institution and as a method of inquiry has different meanings and different connotations for various groups.

The conventional image of science is that it is asocial, non-political, complicated, expert, and

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progressive. It considers science as something that is found outside society. So, it's a special endeavor controlled and managed by scientific and technical expertise. (Andrew Webster, 1991). On another end science is considered as a social institution like any other social institution, which is tremendously influenced by the society and sometimes shaped and reshaped by socio-cultural and political factors. Sometimes it is seen as negative and a factor even harmful to our survival, so, there is difference of opinion on science and technology at the epistemological level and application level.

Science movements across the globe were influenced by the concept of science put forward by British scientist and science historian J. D. Bernal. He played a central role in the political radicalization and mobilization of British scientists during 1930s. (Hobsbawn, Eric,1999). In 1939 he published his seminal work The Social Function of Science. It was the first attempt to present a social analysis of what science does, what science could do, to examine how scientific research and the submission of science interact with the aims of society, and to formulate a coherent policy on science. (Swann, Brenda, 1999).

He regarded science as a organization of progressive knowledge which helps in the development of capitalism, which now needed to be connected to the coming revolution of the masses. The distortions and anti-people developments in the application of science occurred during the pursuit of science within the capitalist project. Their larger consequence is evident in the application of science and technology. The answer to this is to apply science and technology for greater social good, empower people with scientific knowledge. Bernal's work in the science of science created a great shift in the understanding of science in the 20th century and this new understanding has led to the mobilization of people for the cause of science.

Bernal, in another significant work, Science in History, identified five aspects in which science appears in contemporary world. These aspects of modern science distinguish it from other social institutions. Science, according to Bernal is so old and it undergoes so many changes and is still in the same process. So, the understanding of science as a single phenomenon is difficult. It is a multi-dimensional activity ranging from the institutional character to a complex source of ideas that influence the molding of belief and attitude of human beings to the universe. The five aspects, according to Bernal, are: 1) Science as institution. 2) Science as method. 3) Science as a collective tradition of knowledge. 4) Science as a main factor in the maintenance and development of production. 5) Science as a source of ideas.

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1. Science as an Institution

In the initial period of the development of science it was an individual activity done by an individual scientist in his personal laboratory. And it was largely a part-time or spare-time occupation of the wealthy class in the society. When science grew, especially after the industrial revolution, it turned out to be an intimate part of the production system. And scientific activities became a part of the agendas of the state and other funding agencies. The institutionalization of science as a profession and as an occupational category happened only in the early twentieth century. Institutionalized science is a collective and organized set of knowledge and practice. The social institution of science is an assembly of scientists, finances, laboratory works, university and academicians, departments of state or corporations, technicians etc. They make science a social enterprise and a social institution that organizes society and is simultaneously organized by the society.

In capitalist societies, the institution of science has worked under the patronage of the capitalist class. They finance the functioning of laboratories, factories as well as academic institutions and research activities. They organize scientific activities for the making of profit. The profit motivated scientific and technological development will help a special class of the society. On the other end, in socialist society the function of the patronage is taken over by the popular government at all levels, from factory to farm, laboratory to academic institutions. Within such as system, the scientist must recognize his or her social responsibility and the aim of his activities. And he will prefer those activities that have long term and short-term benefits for the society and nation.

2. Science as a Method.

The second aspect of science, according to Bernal, is that science can be seen as a method to understand and discover the truth about nature and man. The method of science or scientific method is based on several operations, some mental and some manual. But method is not fixed and not outside social and cultural influence; it is subject to continuous amendments in different times and spaces and is influenced by socio-cultural change. The methodology of science consists of observation, experimentation, and verification. Further it involves use of logic or reason. To understand the truth about nature, scientists observe the non-humane and human environment and its interrelation in a manner as far as possibly independent of his or her own sentiments. It means that desire must be subordinated to fact and law. But it does not mean that scientists are totally aliened from the social and cultural context.

The next step in the method of science is the classification and the measurement of the

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observed phenomenon. This method helps practitioners understand any new group of phenomena under study and putting it to the further procedures. The apparatus or the set of material tools are very important for carrying out the scientific operation. The apparatus are not any mysterious tools, but they are simply the tools of ordinary life tuned in to very special purposes. From the observations and experiments, and through the process of classification and measurement with the help of apparatuses, scientists will arrive at laws, hypotheses, or theories of the phenomenon. This is not the end of the scientific method, but it commences the application of science and gives rise to new observations, experiments a theory.

3. Science as a Cumulative organization of Knowledge.

The science is an ever-growing body of knowledge fabricate by the prior set of knowledge build of the experience and action. The cumulative tradition of science differentiates science from all other social institutions. The scientist always deliberately strives to question the existing knowledge system and trying to add new theory or knowledge to the existing one. The cumulative character of scientific knowledge was questioned by Thomas Kuhn (1956). He argues that growth of scientific knowledge is non-linear but is discontinues marked by revolutionary shift in the paradigm. The paradigm shapes the scientific inquiry. According to Kuhn the history of science come across different important stages of development, they are the pre-paradigm phase, acquisition of paradigm, normal science, crisis, and new paradigm.

It's very difficult to trace the history of science; it goes back to social formations in the early stages of human settlement to the modern era of engines and other technologies. The human condition and process of production in different historical times and spaces gave birth to modern science. The temporary needs and experiences of society, especially, upper strata of society led to the development of science. So, science as a cumulative tradition has been growing and is an increasingly organized collection of experience and knowledge.

4. Science as a Means of Production

Science plays a key role in the production of means of the survival of the human being in his material world. The productive aspect of science has made it a special social activity in the industrial and post-industrial societies. The history of human society has been influenced and shaped by the application of new technology in different times and spaces. It's said that the material history of mankind is the history of development in science and technology. It's evident from the early Stone Age to the modern industrial and information age.

Science is a method of understanding the needs and ways of production and it fashions the material to the production process. Social factors influence the selection of the factors of

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production. The productions relations of the system that are influenced by the forces of production are based on expansion of science and technology in the society. The force of production will change rapidly with the accumulation of knowledge, while production relation changes slowly. Science as a means of production has influenced every aspect of human history, from the early periods to the contemporary times.

5. Science as a Source of Ideas

Science as a force of production gives importance to the practical utilization of science and scientific techniques. Science plays another important role as a source of ideas or as a rich intellectual tradition, which transform our consciousness. Science from its early period onwards got legitimacy over other sources of knowledge. It is considered a source of ideal truth. For example, the Darwinian Theory of Evolution changed the consciousness of the modern society from a creationist view of life to evolutionary view of life. The law, the hypothesis and the theory of science explain material and human environment. They are the important sources of the intellectual tradition of the modern time which govern the socio-political life.

These five aspects of science allow a broader understanding of science at an epistemological and practical level. Social studies of science, technology see science as a broader endeavor influenced by socio-economic and cultural factors. In this study I use the concept of science in these broader senses, which help us understand science in the context of social movements. The science movements across India use science in this sense. The science organizations also used science in this boarder framework.

Social Studies perspective of Science and Technology

Social studies perspective of science, or science of science, is an inter-disciplinary research field that examines the historical, political, cultural, social, conceptual, and practical aspects of science and its social consequences. As a trans-disciplinary or interdisciplinary field of study and research, it draws its literature, concept, theory and method from philosophy, history, sociology, anthropology etc. For example, in the initial period of the discipline, its theoretical orientations were adopted from structural functionalism, like that in the works of Robert Merton, and Marxism, as in the works of Boris Hessen, J.D Bernal and others. In contemporary science studies draw its theoretical orientation from critical theory, symbolic interactionism, ethnomethodology, and feminist cultural studies.

The broad field of Science and Technology Studies (STS) is not merely an academic

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enterprise, but it is extended to a wider spectrum of activities. STS scholars are from different walks of life. Academicians, activists, scientists, doctors, decision makers, engineers, and others constitute these scholars. They are patrons on matters of equity, policy, politics, social change, national development, and economic renovation.

Stephen H. Cutcliffe (2005) identifies four interlinked tenets or concepts that go beyond the simple disciplinary boundaries and serve as a core body of science studies and practice. They are constructivism, contextualism, problematization and democratization. Constructivism serves as the main thrust of the science and technology studies. STS considers scientific and technological developments as constructed and mediated by the social and cultural contexts. It rejects the concept of the value-free, neutral, objective, asocial knowledge and practice of science and technology. Though it does not deny the nature of physical reality of science and technological artifacts, it emphasizes that construction of knowledge and science are socially mediated processes.

Contextualize of science in science studies highlights the socio-political, economic, and cultural context in which the emergence and practice of science occurs. Without the process of contextualization, it becomes difficult to understand science. It means that scientific and technological artifacts are developed and incorporated in society according to the socio-cultural context. The scholars in the field of scientific and technological studies try to unearth this context in a critical way to understand science.

As science is socially constructed and contextualized it will have certain societal implications. This implication leads to positive and negative impact upon the society in which science is applied. The sociological study where science and technology will problematize negative implication of science and technology in different socio-political contexts. The thrust of science studies on social movement problematizes new developments in the areas of science and technology and make a cost-benefit analysis of its applications. Sometimes it threatens the official standpoint of the mainstream science.

The problematic nature of scientific and technological implications appeals for a democratic control over scientific practices and technological artifacts. And as it is directly related with people's society and surroundings, techno-science needs a wide range of people’s participation. The activist dimension of science studies provides a conceptual and practical output for the development of science in a democratic setup. These tenets of scientific and technological study help the academic practitioner and social activist get some conceptual and theoretical tools to understand science and technology.

Activism-oriented studies in science or politically engaged scholarship in science gets attention in academic fields. This stream of scholarship actively engages with conceptual development in the field of scientific and technological studies while expressing concern over the socio-cultural and political impact of the science. It also participates in the policy making process. Woodhouse et al (2002) called this group of scholars as 'constructivist' group; they considered science as a social institution that emerged and developed with constant interaction with the society and vice versa; they promoted techno science that helps to develop a democratic, environmentally sustainable, socially just society. The re-constructivist STS scholarship '…. denote a wide domain of scholarships that is normative in orientation and activist in sympathies' (Edward Woodhouse, 2002). This is because all scientific inquiries and technological developments occur in different social and cultural contexts and participants have cognitive, emotional, interpersonal, and other commitments, ideologies, and biases.

According to Woodhouse et al, the constructivist tradition in science and technology studies (STS) has played an important role in exploring the techno scientific controversies and policy making. Activism-oriented scholars can influence two classic constituencies of STS, like other scholars from the same discipline and policymakers. Through this process they can demystify the rhetoric of mainstream or official 'good science'. In the policy making process, the constructivist science studies can provide insight for policy making. It can offer socially just, environmentally stable scientific practice and technological artifacts. Its thoughtful partisanship in socially beneficial, ecologically sustainable, ethical practice of science helps assist and encourage science movements. The primary commitment of the activism- oriented STS research is towards the grass root level social change, and they choose the social and environmental problems related with science and technology as their field of study.

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