Course: Foundations of Science Education (6435)
Semester: Autumn, 2021

ASSIGNMENT No. 2

Q.1 Discuss Jerome Burner's Theory of Education. How this theory is supportive for science teachers for teaching of science?

The American educational psychologist Jerome Burner proposed a system of classifying different types of learning in terms of the degree of complexity of the mental processes involved. He identified eight basic types, and arranged these in the hierarchy. According to Jerome Burner, the higher orders of learning in this hierarchy build upon the lower levels, requiring progressively greater amounts of previous learning for their success. The lowest four orders tend to focus on the more behavioral aspects of learning, while the highest four focus on the more cognitive aspects.

Learning has been defined as a relatively permanent change in a behavioral tendency, the result of reinforced practice. Learning, an inferred state of organism, should be distinguished from performance, an observed state of the organism, should be distinguished from performance, an observed state of the organism. Learning events consist of stimuli, learner and responses.

The most complete description of Jerome Burner's classes of behavior appears his 'The conditions of learning'. Here he distinguishes eight types of learning, beginning with the simple forms and ending with the complex. Although he refers to these classes as learning types, he is primarily interested in the observable behavior and performance which ware the products of each such class.

Signal learning

This is the simplest form of learning, and consists essentially of the classical conditioning first described by the behavioral psychologist Pavlov. In this type of learning the animal or individual acquires a conditioned response to a given signal. Pavlov studied such learning in great detail. In it the responses are diffuse and emotional and the learning is involuntary. Examples are the withdrawal of the hand upon sight of a hot object, the salivation of a dog upon hearing food poured into his metal feeding dish, and the tearing of the eyes upon sight of an onion. The signals are the sight of the hot object, the sound of food being poured in the dish, and the sight of the onion. The conditioned responses are withdrawal of the hand, salivation, and tearing of the eyes.

Stimulus-response learning

This somewhat more sophisticated form of learning, which is also known as operant conditioning, was originally developed by Skinner. In this kind of learning, exemplified by animal training, the animal makes precise responses to specific stimuli. At first this training usually requires the use of a leash and a choke chain. As the dog learns particular responses for particular jerks of the leash and chain, his master rewards him with pats and praise. Later the master does not have to use the leash and chain; the animal sits, stays, or lies down upon hearing the simple verbal command. Whereas the responses in signal learning are diffuse and emotional, the responses in stimulus-response learning (often called operant conditioning) are fairly precise. Stimulus-response (SàR) learning may be used in acquiring verbal skills as well as physical movements. For example ,

the child may learn to say "Mama" on request, or an adult may learn the appropriate response to the stimulus of a word in a foreign language.

Chaining

This is a more advanced form of learning in which the subject develops the ability to connect two or more previously-learned stimulus-response bonds into a linked sequence. It is the process whereby most complex psychomotor skills (eg riding a bicycle or playing the piano) are learned.In this type of learning the person links together previously learned S-R's. The links may involve physical reactions such as an animal learning a series of tricks, each of which gives the cue to perform the next trick.This type of learning often seems to occur so naturally that we do not notice the specific series of events which led to it. Jerome Burner uses the example of a child who learns to say "doll" at the sight of a doll, then learns to lie down, hug the doll, and say "doll".

Verbal association

This is a form of chaining in which the links between the items being connected are verbal in nature. Verbal association is one of the key processes in the development of language skills.This learning is a type of chaining, but the links are verbal units. The simplest verbal association is the activity of naming an object, which involves a chain of two links: An observing response enables the child to identify properly the object he sees; and an internal stimulus enables the child to say the proper name. When the child can name an object "ball" and also say " the red ball" he has learned a vernal association of three links. Jerome Burner calls another common verbal association translation responses; in these the learner frequently acquires verbal associations by verbal mediation- an internal link which helps him associate.

Discrimination learning

This involves developing the ability to make appropriate (different) responses to a series of similar stimuli that differ in a systematic way. The process is made more complex (and hence more difficult) by the phenomenon of interference, whereby one piece of learning inhibits another. Interference is thought to be one of the main causes of forgetting.In this type of learning the student must learn different responses for stimuli which might be confused. The student learns to distinguish between motor and verbal chains he has already acquired. Teachers, Jerome Burner suggests, engage in discrimination learning when the devise means for calling each student by his correct name.

Concept learning

This involves developing the ability to make a consistent response to different stimuli that form a common class or category of some sort. It forms the basis of the ability to generalise, classify etc.In learning a concept we respond to stimuli in terms of abstract characteristics like color, shape, position and number as opposed to concrete physical properties like specific wavelengths or particular intensities. In concept learning the student's behavior is not under the control of particular physical stimuli but of the abstract properties of each stimulus. Concepts have concrete references even though they are learned with the use of language.

Rule learning

. This is a very-high-level cognitive process that involves being able to learn relationships between concepts and apply these relationships in different situations, including situations not previously encountered. It forms the basis of the learning of general rules, procedures, etc.In learning a rule we relate two or more concepts. Rules are, in effect, chains of concepts. We may represent knowledge as a hierarchy of rules, in which we must learn two or more rules before learning a higher order rule which embraces them. If the student has learned the component concepts and rules, the teacher can use verbal instruction alone in leading the student to put the rules together.

Problem solving

This is the highest level of cognitive process according to Jerome Burner. It involves developing the ability to invent a complex rule, algorithm or procedure for the purpose of solving one particular problem, and then using the method to solve other problems of a similar nature.

In the set of events called problem solving, individuals use rule to achieve some goal. When the goal is reached, however the student has learned something more and is then capable of new performances using his new knowledge. What is learned, is a higher order rule, the combined product of two or more lower order rules. Thus the problem solving requires those internal events usually called thinking.. Without knowledge of the prerequisite rules, the problem can not be solved.

Q.2 Define constructivism. What are different types of constructivism? Which type of constructivism is the most useful for science teachers?

Constructivism is an important learning theory that educators use to help their students learn. Constructivism is based on the idea that people actively construct or make their own knowledge, and that reality is determined by your experiences as a learner. Basically, learners use their previous knowledge as a foundation and build on it with new things that they learn. So everyone's individual experiences make their learning unique to them.

Constructivism is crucial to understand as an educator because it influences the way all of your students learn. Teachers and instructors that understand the constructivist learning theory understand that their students bring their own unique experiences to the classroom every day. Their background and previous knowledge impacts how they are able to learn. Educators are able to use constructivist learning theory to help their students understand their previous knowledge. If you're a current or aspiring educator, it's important to get the education and credentials you need. But it's also important to understand learning theories and how they impact you and your students. This guide will tell you more about the constructivist learning theory and how it helps you as a teacher.

Principles of constructivism.

There are many specific elements and principles of constructivism that shape the way the theory works and applies to students. Learn about the different principles of constructivism and how they make up the whole theory.

- Knowledge is constructed. This is the basic principle, meaning that knowledge is built upon other knowledge. Students take pieces and put them together in their own unique way, building something different than what another student will build. The student's previous knowledge, experiences, beliefs, and insights are all important foundations for their continued learning.
- People learn to learn, as they learn. Learning involves constructing meaning and systems of meaning. For example, if a student is learning the chronology of dates for a series of historical events, at the same time they are learning the meaning of chronology. If a student is writing a paper about history, they are also learning principles of grammar and writing as well. Each thing we learn gives us a better understanding of other things in the future.
- Learning is an active process. Learning involves sensory input to construct meaning. The learner needs to do something in order to learn, it's not a passive activity. Learners need to engage in the world so they are actively involved in their own learning and development. You can't just sit and expect to be told things and learn, you need to engage in discussions, reading, activities, etc.
- Learning is a social activity. Learning is directly associated to our connection with other people. Our teachers, our family, or peers, and our acquaintances impact our learning. Educators are more likely to be successful as they understand that peer involvement is key in learning. Isolating learnings isn't the best way to help students learn and grow together. Progressive education recognizes that social interaction is key to learning and they use conversation, interaction, and group applications to help students retain their knowledge.
- Learning is contextual. Students don't learn isolated facts and theories separate from the rest of our lives—we learn in ways connected to things we already know, what we believe, and more. The things we learn and the points we tend to remember are connected to the things going on around us.
- Knowledge is personal. Because constructivism is based on your own experiences and beliefs, knowledge becomes a personal affair. Each person will have their own prior knowledge and experiences to bring to the table. So the way and things people learn and gain from education will all be very different.
- Learning exists in the mind. Hands-on experiences and physical actions are necessary for learning, but those elements aren't enough. Engaging the mind is key to successful learning. Learning needs to involve activities for the minds, not just our hands. Mental experiences are needed for retaining knowledge.
- Motivation is key to learning. Students are unable to learn if they are unmotivated. Educators need to have ways to engage and motivate learners to activate their minds and help them be excited about education. Without motivation, it's difficult for learners to reach into their past experience and make connections for new learning.

Types of constructivism.

There are different types of constructivism that educators can use to find success with this learning theory.

- Cognitive. Cognitive constructivism focuses on the idea that learning should be related to the learner's stage of cognitive development. These methods work to help students in learning new information by connecting it to things they already know, enabling them to make modifications in their existing intelligence to accommodate the new information. Cognitive constructivism comes from the work of Jean Piaget and his research on cognitive development in children.
- Social. Social constructivism focuses on the collaborative nature of learning. Knowledge develops from how people interact with each other, their culture, and society at large. Students rely on others to help create their building blocks, and learning from others helps them construct their own knowledge and reality. Social constructivism comes from Lev Vygotsky, and is closely connected to cognitive constructivism with the added element of societal and peer influence.
- Radical. Radical constructivism is very different from cognitive and social constructivism. It focuses on the idea that learners and the knowledge they construct tell us nothing real, only help us function in our environment. The overall idea is that knowledge is invented, not discovered. The things we bring to the table make it impossible for us to have truth, only interpretations of knowledge. This theory was developed by Ernst von Glasersfeld in 1974.

Constructivism in education.

It's important to understand how teachers can apply constructivism inside their classroom to create a unique learning environment for students. In constructivist classrooms, the teacher has a role to create a collaborative environment where students are actively involved in their own learning. Teachers are more facilitators of learning than actual instructors. Teachers must work to understand the preexisting conceptions and understanding of students, then work to incorporate knowledge within those areas. Teachers will also need to adjust their teaching to match the learner's level of understanding.

Constructivist classrooms rely on four key areas to be successful:

- Shared knowledge between teachers and students.
- Shared authority between teachers and students.
- Teachers act as a guide or facilitator.
- Learning groups consist of small numbers of students.

Constructivist classrooms are often very different from normal classrooms in many ways. Constructivist classrooms focus on student questions and interests, they build on what students already know, they focus on interactive learning and are student-centered, teachers have a dialogue with students to help them construct their own knowledge, they root in negotiation, and students work primarily in groups.

Constructivist classrooms often have teachers who do small group work, collaborative and interactive activities, and open dialogues about what students need in order to find success.

Disadvantages of constructivist methods.

The biggest criticism of constructivist learning is its lack of structure. Some students need highly structured and organized learning environments to thrive, and constructivist learning focuses on a more laid-back method to help students engage in their own learning.

Grading is often removed from constructivist classrooms and places more value on student progress, which can lead to students falling behind and not meeting standardized grading requirements.

If you are hoping to become a teacher, a degree is crucial to getting on the right path. Additionally, it's valuable for teachers to understand different learning theories and how they impact their classroom and their students.

Q.3 Identify and explain social issues which can be resolved through science education.

In the past, our scientific methods and institutions have tended to emphasize the study of individual natural processes rather than systems, analysis more than synthesis, and understanding nature more than predicting its behaviour. And in many instances, science has focussed on short-term, small-scale problems, often in monodisciplinary mode, rather than on long-term, large-scale or integrated problems. While these approaches and perspectives have built up a considerable base of knowledge and led to a vast portfolio of useful technologies, especially in the 20th century, many of the problems now facing humankind can be solved only if we approach science more holistically. Greater effort is needed to understand integrated natural systems on multiple time and space scales.

Scientific findings must also be applied at the right scales. The impact of technological interventions on individual people, communities and the environment must also be carefully considered. To do this, science needs to become more multidisciplinary and its practitioners should continue to promote cooperation and integration between the social and natural sciences. A holistic approach also demands that science draw on the contributions of the humanities (such as history and philosophy), local knowledge systems, aboriginal wisdom, and the wide variety of cultural values.

The influence of science on people's lives is growing. While recent benefits to humanity are unparalleled in the history of the human species, in some instances the impact has been harmful or the long-term effects give causes for serious concerns. A considerable measure of public mistrust of science and fear of technology exists today. In part, this stems from the belief by some individuals and communities that they will be the ones to suffer the indirect negative consequences of technical innovations introduced to benefit only a privileged minority. The power of science to bring about change places a duty on scientists to proceed with great caution both in what they do and what they say. Scientists should reflect on the social consequences of the technological applications or dissemination of partial information of their work and explain to the public and policy makers alike the degree of scientific uncertainty or incompleteness in their findings. At the same time, though, they should not hesitate to fully exploit the predictive power of science, duly qualified, to help people cope with environmental change, especially in cases of direct threats like natural disasters or water shortages.

The current trend toward privatization in many countries is influencing the focus and practice of science. While in some instances the net result may be to increase research capacity and knowledge in selected areas, there is major concern that the trend may be undermining public-sector science, especially fundamental research and efforts to solve socially important problems of no interest to commercial enterprises. Patent protection of private intellectual property, for example, makes the job of public research more difficult. There is also concern over the social implications of private ownership and control of technology, and its effect on broad public scientific literacy, and on options for public choice.

Another major trend shaping science is globalization. The end of the Cold War, growing technology demand from emerging economies, world recognition of the interconnectedness of the planet's biophysical systems and improved communications, especially via the Internet -- all these forces are boosting cross-border scientific cooperation and information exchange between individual researchers, institutions and governments. However, much of the expansion is occurring in just a handful of scientifically advanced countries. For science to be truly global, more effort is needed to ensure all countries, rich and poor, and a wide range of world cultures are included in collaborative research and technology transfer. This is especially important in areas like global climate change which will affect, sooner or later, all human beings. With the right policies in place, joint scientific work in critical areas such as the Arctic, for example, could serve as a model for other types of global cooperation.

A major challenge for global science is to find institutional arrangements conducive to success. The proliferation of international networks and programs, the so-called "acronym jungle", reflects a rather ad hoc approach, necessitated in part by the narrowness of purposes of established scientific institutions and the lack of strategic, integrated support by national governments in areas like global change or international aid. What is needed is the formation of true international partnerships that allow scientists in different disciplines and countries to fully support each other's aims and share resources and management duties to mutual advantage.

Scientists and scientific institutions should

- promote multidisciplinary approaches to research, encourage cooperation between the social and natural sciences, and draw lessons from the humanities, local knowledge systems and aboriginal wisdom;
- encourage a holistic approach to problem solving that takes into account a realistic range of socioeconomic conditions and effects, as well as multiple time and space scales, where appropriate;
- carefully explain the implications and the inherent limitations of their research findings to the public;
- fully exploit the predictive power of science to serve social needs with candid awareness of the limitations of scientific predictions;
- promote the inclusion of scientists from resource-poor countries in international cooperative projects and maximize their access to information and technology;

- encourage the creation of science-coordination mechanisms at the highest level of the United Nations, fully involving the governments of all countries, as a way to promote integrated responses to global problems.

Communication and Education

Within the general public, there is certain measure of mistrust and even fear of science and technology (S&T). Some is based on public experience, but much is the consequence of a significant communications gap between scientists and society. Many reasons are advanced for these attitudes: public ignorance or misunderstanding of science, inaccurate or biased media coverage, uneven distribution of the costs and benefits of science among different sub-groups in society, lack of public control over the applications of S&T, and the inability of some scientists to communicate ideas in plain language. The issue of nuclear waste disposal is one example of how the gap between scientific findings (which, in this case, suggest that safe disposal technologies exist that are at least as safe as other industrial risks accepted by society) and public opinion and behaviour (continuing opposition to the use of such technologies) may sometimes appear intractable, that is, not amenable to solution simply through improved communication or further technical research.

Good scientific communication via the mass media is especially important in those areas directly and strongly affecting people's lives — for example, before, during and after natural disasters such as storms, volcanic eruptions and earthquakes, as well as in the general area of global change or depletion of natural resources. In communicating their ideas, scientists should make clear the limitations of their predictions and other pronouncements. But they should not shy away from public pronouncements just because their messages contradict public wishes or expectations; indeed, they should be prepared for negative reactions in those instances, and carefully explain the basis for their scientific conclusions or opinions.

Apart from communication by the mass media which is largely unidirectional, communication in the sense of an ongoing dialogue between scientists, the public, and policy-makers is also important. This may take many forms: public policy consultations and review committees, science fairs, open houses, and public information services provided by universities, research institutes and private companies. As the demand for transparency and accountability in science grows, communication of this type — as well as public participation in decision making about the applications of S&T — becomes imperative. Unfortunately, resources for such dialogue are lacking not only among scientific institutions but among those groups in society who have a particular stake in scientific developments and therefore something to gain through contact with scientists. Increasing privitization of scientific activity also discourages open communication of scientific findings and uncertainties.

Science education, particularly training in multidisciplinary and team approaches to research, is also in need of reinforcement. Many science education programs still focus on individual student assignments and individual evaluation, whereas the trend in both the public and private sector is toward team work, and the needs of society are increasingly met by the concerted efforts of many areas of investigation. Science, if it is to appeal strongly

to youth, also needs to be demystified by educators — that is, presented in an attractive, stimulating fashion, with the abstractions of theory strongly linked to everyday life.

Furthermore, students need to be more fully involved in public discussion of science and its applications. Not only are they the ones who will be most affected by the current direction of science, they are also the scientists and policy makers of tomorrow.

- To improve the quality of science journalism, the mass media should engage more journalists with scientific training. At the same time, the mass media and specialized educators should be enlisted to help train scientists or their spokespersons in the fundamentals of public communication and to familiarize them with the expectations and operating parameters of the mass media.
- The concept of scientific clearing houses — services to help journalists interpret scientific data, decipher technical language, and distinguish scientifically credible claims from unsubstantiated ones — should be promoted. UNESCO national commissions should also consider setting up scientific information services aimed at improving the quality and quantity of science stories in the media and ensuring that differing viewpoints are presented.
- Science community partnerships -- for example, between research institutes, private firms, the media, and governments — are an effective and practical way to share the costs of communicating science to the public. These should be encouraged.
- Educational authorities should encourage teamwork training and multidisciplinary approaches to science education. They should also attempt to demystify science to make it attractive to a larger proportion of students. University and private-sector experience with team-oriented research should be documented and analyzed with a view to identifying the best current practices in North America.

Science in the developing world differs from that in the industrialized world in three main ways: budgets are much smaller, research agendas are different because the socioeconomic and biophysical problems to be solved are different, and there is a lower level of access to and public understanding of scientific information and technology. The North-South knowledge gap is viewed by some as the most pressing social and economic aspects of modern science.

Many developing countries have well-qualified scientists but often they are few in number and lack the resources and political support needed to solve complex problems or to apply their knowledge to national issues. In Mexico, where agriculture remains an important part of the national economy, scientific work related to food production and food security is complicated by a web of social problems such as rural poverty, social discrimination against peasants, migration to cities because of changes in land use, weak transportation and marketing services, and lack of farmer access to credit. In the area of health, too, the problems of developing countries are much different than those of developed countries. Chagas ' disease and schistosomiasis, for example, are endemic in many developing nations, yet they receive very little attention by health scientists and pharmaceutical firms in industrialized countries.

While there are number of North-South cooperative programs to support science in developing countries and improve technology transfer, much more should be done. Water management, tropical disease research, and energy-efficiency technology were identified as areas where the current co-operative programs are weak, but in which the industrialized countries can provide valuable assistance to developing countries.

In the case of international research on large-scale problems like global change, most developing countries are unable to contribute to those scientific components requiring sophisticated research facilities and technologies. However, there are other effective but inexpensive ways for them to participate, such as regional monitoring and carrying out studies of local conditions and effects. It was suggested, for example, that Mexico could contribute to research on climate change by carrying out, at very low cost, epidemiological studies of a possible link between urban air quality and recently observed seasonal increases in cardiovascular disease and pregnancy-related hypertension. ICSU has an important role in ensuring that developing countries are involved in global change studies on imaginative but affordable and practical ways.

Another symptom of the North-South science gap is the inequitable distribution of profits generated by new technologies and products based on plant genetic resources obtained from developing countries.

- Efforts should be stepped up to give developing countries better access to scientific expertise, information and technology, especially in the areas of disaster relief, health, energy, and water management. In particular, the scientific and technical know-how of military organizations should be harnessed to monitor and alleviate the effects of disasters around the world.
- Measures are needed to systematically involve all countries in research on global change. Developing countries' scientific knowledge of local conditions and effects should be harnessed in the worldwide effort to understand, predict and adapt to global change and the growing understanding of changes in climate, water, and soil incorporated in international assistance programmes.
- Countries and communities should be fairly compensated for their contribution of plant genetic resources that lead to commercially profitable technologies.
- As a priority, science should address the basic needs of the sick and disadvantaged in the poorest countries.

Economics versus Sustainable Development

Science today seems caught in a cross-fire between two opposing world views. On the one hand, science is a major tool of the ideology currently driving the world economy, namely that of the free market system, continual growth and the pursuit of personal wealth. On the other hand, science is increasingly being called on to produce knowledge and technology that promote environmentally sustainable, people-oriented development and long-term management of resources.

The world economy continues to rely heavily on cheap oil, a non-renewable resource and major contributor of greenhouse gases. Fossil fuels - oil, coal, natural gas - will continue to power world industry for several decades. The fact that they will do so despite the availability of technically feasible alternative "green" energy

technologies, brings the dilemma into sharp relief. Examples of the conflict between current economic forces and the need for sustainable development can be found in many other domains as well. The imposition of structural adjustment policies by international financial institutions, for example, has forced some countries to reorient agricultural research and production to focus on cash crops that generate foreign currency rather than food crops for local consumption. In some cases, such policies have put food security and the continued production of the land in jeopardy, created enormous personal hardship for citizens, and led to social unrest.

Free trade arrangements, too, may pose a threat to some of the underlying components of sustainable development, affecting biodiversity, community self-reliance, and local knowledge systems. In some cases, the elimination of trade barriers between countries has led farmers to abandon the cultivation of traditional crop varieties that were well adapted to local conditions and tastes, in favour of imported varieties that may respond better to newly expanded markets.

Deregulation and privatization are two trends aimed at improving commercial competitiveness, and stimulating economic growth. Yet in some sectors such as energy production and food it is becoming clear that these trends cannot be reconciled with the requirement imposed by sustainable development that hidden environmental and social costs of economic production — that is, costs bourne by present or future society but not normally reflected in prices of goods and services like energy, be taken into account.

In the past, developments in the energy field have had more to do with the protection of vested economic interests than with concern for the public good or environmental conservation. The prospect of that approach being perpetuated is a major concern for the future of energy science, since fossil fuels are a finite resource and a major contributor of greenhouse gases, and research or energy alternatives is handicapped.

- Policy makers must accept that, for certain key areas like energy development, decisions must not be based only on political expediency — such as the prospect of short-term economic benefits and job creation. To do so denigrates the role of forward-thinking research and development (R&D) and undermines long-term social development. Rather, what is needed is a vision of the world that looks "seven generations" ahead, in the manner of the holistic philosophies of North American aboriginal people.
- Public debate on the dangers of "consumptive" lifestyles typical of the industrialized countries, needs to be reactivated. If everyone on the planet lived as many North Americans do, we would need the resources of "seven Planet Earths". As this is clearly impossible, the implications of inevitable major changes soon to come should be openly discussed at all levels of society.
- Scientists need to cultivate a new vision of science — one that promotes the development of sustainable "closed" systems of production and consumption, which are compatible with the recycling behavior and equilibrium of natural systems.
- Agencies that provide research grants should be broader in their terms of reference and more neutral and flexible so that scientists are not continually pushed to find short-term solutions when long-term ones

are needed. In some countries, the allocation of research funds is controlled by small powerful groups who engage in favoritism for their own personal gain or prestige. Governments should ensure that systems for evaluating and funding project proposals are fair, objective, and transparent.

Science Policy and Ethics

Scientific advances are never, in themselves, a guarantee of social benefit. Technology has to be treated as a servant of society, not a master. Increasing commercial productivity, while at the same time necessary, unemployment and poverty is not a socially acceptable solution. Science must be fully integrated with broad societal needs, but this tenet is not yet fully accepted. One reason for public mistrust of science is that ordinary people feel they will sometimes end up being the ones to suffer the costs of technological innovation. It was suggested repeatedly at the North American meeting that the time has come to introduce an international code of ethical conduct for scientists to ensure that science is directed for the public good.

Scientists in their daily work are sometimes isolated from mainstream society, making it difficult for them to be clearly aware of public needs. Conversely, policy makers, in need of sometimes urgent advice on technical matters, sometimes urgent, may be unaware of the scientific expertise residing under their very noses. Society has much to gain by the proactive involvement of scientists in policy making.

Medical biotechnology is a leading-edge area of science in which the pace of progress is perhaps faster than society's capacity to deal with the ethical and social implications. Genetic research, while offering major benefits for disease diagnosis and treatment, also poses serious questions about the nature and sanctity of human life and the protection of human rights. The possibility that genetic technology could be commandeered by powerful groups to pursue goals in their own interests but which may be socially destructive or discriminatory is not to be considered lightly. It is an issue of particular importance to disabled persons. Greater dialogue between scientists, policy makers and the public, especially those groups disproportionately affected by technological developments, is clearly needed.

A major concern is that recent advances in health sciences will lead to the "genetification of medicine", that is, a trend toward understanding and explaining human beings and human health largely in terms of genes and their interactions. A worry here is that the role of environmental and social factors will increasingly receive insufficient attention, leading to a one-dimensional view of diseases and disabilities.

A further ethical issue for science is what has been referred to as the "commodification" of basic human needs such as food, shelter, clothing, fuel and health services. In many countries, many of these items have traditionally been supplied through non-monetary social support structures, often family-based. As cash economies and government welfare programmes increasingly treat these necessities of life simply as commodities to be bought and sold, there is a serious risk that technological innovations, stimulated by scientists working within a commercial framework, will be exploited mainly by well-to-do minorities, with little or no benefit to the poor. The potential of science to improve human social conditions in non-material ways needs much more attention.

Q.4 Elaborate different aspects of science education for economic development.

There are many reasons to believe that increased educational opportunity and achievement lead to social progress. The aim of this chapter is to examine how educatıon can promote social progress. Answering this question is not straightforward. Education has multiple aims, and the way in which education is provided – educational governance, educational institutions, educators, curriculum, and pedagogy – all matter a great deal. We cover each of these topics in this chapter, looking at trends across the globe and seeking ascertain what scholars know about better and worse forms of educational provision.

To understand the connection between education and social progress, we distinguish among four distinct aims of education: economic, civic, humanistic, and equity promotion.

Each of these goals can be understood from an individual and collective perspective.

1. Education develops productive skills, and this is valuable for the individual, to advance in the labor market and for society, to improve and maintain prosperity and compete in a globalized economy.
2. Education develops civic skills, and this is valuable for the individual, to allow for meaningful participation in civil society and political life, and for society, to benefit from an informed and engaged citizenship.
3. Education develops human talents and interests, and this is valuable for the individual, allowing for personal flourishing, and for society, since the expansion of knowledge and human achievement are valuable for their own sake.
4. Education can be a vehicle for equity and greater social inclusion, or when absent, poorly delivered or unfairly distributed, a vehicle for injustice and greater social exclusion.

Some of these connections are obvious. The basic values of human progress include well-being, freedom, solidarity, social relations, esteem and recognition, and cultural goods. The humanistic purpose – developing human talents and interests – facilitates well-being (some might say actually constitutes well-being), cultivates capacities essential to freedom, promotes esteem and recognition, and contributes to cultural goods. The civic purpose – developing civic skills and dispositions – help establish the basis of social relations, develop bonds of solidarity among citizens, and encourage esteem and recognition. And insofar as education is a vehicle for equity and social inclusion, it is an essential mechanism for nearly every value on the list.

Overall, education is about the unleashing of human capabilities: economic, civic, and humanistic. When education is successful, it enables individuals not merely to exercise their agency in participating in economic, civic, and humanistic activity but also to shape or re-shape economic, civic, and humanistic life. When we think about the relationship between education and justice, we reach two additional conclusions. First, justice demands that every individual be afforded equitable educational opportunities. Second, the provision of educational opportunity, across all four goals, is essential to social progress and the advancement of justice. This includes access to education, experiences within it, and outcomes from it.

In the first part of the chapter, we present a broad view of education in the world today, showing how formal education has expanded in the last decades, and emphasizing how it relates to citizenship, growing opportunities for social mobility, economic development and equity. We take stock of what has been achieved and is still to be done to improve access to quality education in the poorer parts of the word, through the Sustainable Developed Goals fostered by global community, which is mostly concerned with initial and mandatory education; and take a closer look at the special roles played by vocational and tertiary education. Each of these dimensions are subject to controversies, which we try to take into account, while emphasis the overall positive effects of education for social progress.

The crucial role education can play in promoting social progress obviously depends on the governance of education, on educational institutions and educators, as well as on the content and pedagogy of education. Consequently, it is necessary to consider at least three levels of effects, which are strongly interconnected: the level of concrete instruction in class (microlevel). Educators are the main actors at this level; the level of institutions (schools, pre-schools, kindergartens, universities, etc.; the mesolevel). Here principals have a substantial influence; and the level of the educational system (the macrolevel). Educational policymakers and authorities are the central actors here.

In the second part of the chapter we discuss facilitators and barriers to education as a means for social progress in three subsections. The first subsection focuses on governance of education and therefore the macrolevel. Here we discuss how modes of governance affect the potential of education to contribute to social progress. The second subsection targets institutions and educators. That means it focuses the meso- and microlevel. This subsection describes characteristics of successful educational institutions and competencies educators and principals should have to contribute to the four goals of education. The third and final subsection focuses on content of education and pedagogy and targets all three levels. Concretely, it discusses the core curriculum for the 21st century and especially identity formation as an important basic theme in education, as well as two important trends in pedagogy: learner-centred education and the role of technology. All three subsections provide final recommendations.

Education can be studied from a vast array of disciplinary approaches, the issues and priorities for education policies vary enormously among developed and developing societies and social groups, different cultural contexts and philosophical orientations, and are often controversial. This chapter cannot expect account for this enormous variety, nor gloss over the different and opposing views that may exist. It can, however, provide a broad view of the relevance of education for social progress, what has been achieved, what are the pending issues in different contexts, and identify some of the main issues raised by the social sciences to make education more accessible and meaningful for all.

The twentieth century witnessed a major growth in the provision of educational opportunity across the globe, which is a good thing. Landmark multinational agreements such as the 1948 Declaration of Human Rights and

the more recent United Nations Sustainable Development Goals (SDGs) put forward a right for all children to be educated.

There are many reasons to believe that increased educational opportunity and achievement lead to social progress. The aim of this chapter is to examine how can educatıon promote social progress.

Answering this question is not straightforward. Education has multiple aims, and the way in which education is provided – educational governance, educational institutions and educators, curriculum, and pedagogy – all matter a great deal. We will cover each of these topics in this chapter, looking at trends across the globe and seeking ascertain what scholars know about better and worse forms of educational provision.

To understand the connection between education and social progress, we must first distinguish among four distinct aims of education: economic, civic, humanistic, and equity promotion.

Each of these goals can be understood from an individual and collective perspective.

Education develops productive skills, and this is valuable for the individual, to advance in the labor market and for society, to improve and maintain prosperity and compete in a globalized economy.

1. Education develops civic skills, and this is valuable for the individual, to allow for meaningful participation in civil society and political life, and for society, to benefit from an informed and engaged citizenship.
2. Education develops human talents and interests, and this is valuable for the individual, allowing for personal flourishing, and for society, since the expansion of knowledge and human achievement are valuable for their own sake.
3. Education can be a vehicle for equity and greater social inclusion, or when absent, poorly delivered or unfairly distributed, a vehicle for injustice and greater social exclusion.

These distinct purposes of education connect in multiple ways to the definition of social progress provided in chapter 2. Some of these connections are obvious. The basic values of human progress include well-being, freedom, solidarity, social relations, esteem and recognition, and cultural goods. The humanistic purpose – developing human talents and interests – facilitates well-being (some might say actually constitutes well-being), cultivates capacities essential to freedom, promotes esteem and recognition, and contributes to cultural goods. The civic purpose – developing civic skills and dispositions – help establish the basis of social relations, develop bonds of solidarity among citizens, and encourage esteem and recognition. And insofar as education is a vehicle for equity and social inclusion, it is an essential mechanism for nearly every value on the list.

The definition of social progress also includes a list of basic principles. Once again, there are multiple connections to the distinct purposes of education. The most obvious connection is the identification of "educating and supporting citizens" as a basic principle. Here education is defended mainly for its essential civic role, preparing children for their participation in political life and in civil society and to assume the responsibilities of citizenship.

Two additional principles are important to mention, basic rights and distributive justice. Various United Nations declarations consider primary and secondary education as a basic right that must be guaranteed to every child. And since educational opportunity is not something that an individual can provide on his or her own, we must consider it within the scope of distributive justice. The task of a theory of distributive justice is to identify what principle or principles should structure the distribution of benefits and burdens in a society and to identify to whom -- what people or class of persons -- these benefits and burdens are to be distributed. The provision of schooling is a paradigmatic example of a good that is distributed in some manner or another by virtually every society. So to address the question of education as an important dimension of measuring social progress is to explore the question of how it should be distributed to people.

Overall, education is about the unleashing of human capabilities: economic, civic, and humanistic. When education is successful, it enables individuals not merely to exercise their agency in participating in economic, civic, and humanistic activity but also to shape or re-shape economic, civic, and humanistic life. Education for professional skills not merely prepares people for the workforce; it shapes the labor market itself. Education for citizenship not merely prepares people to participate in civic and political life; it enables social participation that shape political institutions. Education for human talents not merely develops the vast domain of human potential; it advances humanity's storehouse of knowledge and cultural achievement.

When we think about the relationship between education and justice, we reach two additional conclusions.

First, justice demands that every individual be afforded equitable educational opportunities.

Second, the provision of educational opportunity, across all four goals, is essential to social progress and the advancement of justice. This includes access to education, experiences within it, and outcomes from it.

When we observe education across the world today, we see two clear patterns. First, educational opportunity is not everywhere provided to all. Equity is routinely violated. Second, educational policies often weight the economic purpose of schooling with comparatively little attention paid to civic and humanistic aims. Discussion of these observations constitutes the major part of the remainder of this chapter.

The chapter has three further sections. In section 2, we take stock of current conditions and challenges in educational provision and distribution on a global scale. In section 3, we consider facilitators and barriers to education as a means to social progress. We examine here three separate domains: (1) governance of education; (2) institutions and educators; and (3) content and pedagogy. In section 4 we provide our conclusions and recommendations.

A final cautionary note: Education can be studied from a vast array of disciplinary approaches, the issues and priorities for education policies vary enormously among developed and developing societies and social groups, different cultural contexts and philosophical orientations, and are often controversial. This chapter cannot expect account for this enormous variety, nor gloss over the different and opposing views that may exist. It can, however, provide a broad view of the relevance of education for social progress, what has been achieved, what

are the pending issues in different contexts, and identify some of the main issues raised by the social sciences to make education more accessible and meaningful for all.

Q.5 What impending trends do you anticipate regarding Science Education in Pakistan?

Education is an integral aspect of every society and in a bid to expand the frontiers of knowledge, educational research must become a priority. Educational research plays a vital role in the overall development of pedagogy, learning programs, and policy formulation.

Educational research is a spectrum that bothers on multiple fields of knowledge and this means that it draws from different disciplines. As a result of this, the findings of this research are multi-dimensional and can be restricted by the characteristics of the research participants and the research environment.

Educational research is a type of systematic investigation that applies empirical methods to solving challenges in education. It adopts rigorous and well-defined scientific processes in order to gather and analyze data for problem-solving and knowledge advancement.

J. W. Best defines educational research as that activity that is directed towards the development of a science of behavior in educational situations. The ultimate aim of such a science is to provide knowledge that will permit the educator to achieve his goals through the most effective methods.

The primary purpose of educational research is to expand the existing body of knowledge by providing solutions to different problems in pedagogy while improving teaching and learning practices. Educational researchers also seek answers to questions bothering on learner-motivation, development, and classroom management.

While educational research can take numerous forms and approaches, several characteristics define its process and approach. Some of them are listed below:

1. It sets out to solve a specific problem.
2. Educational research adopts primary and secondary research methods in its data collection process. This means that in educational research, the investigator relies on first-hand sources of information and secondary data to arrive at a suitable conclusion.
3. Educational research relies on empirical evidence. This results from its largely scientific approach.
4. Educational research is objective and accurate because it measures verifiable information.
5. In educational research, the researcher adopts specific methodologies, detailed procedures, and analysis to arrive at the most objective responses
6. Educational research findings are useful in the development of principles and theories that provide better insights into pressing issues.
7. This research approach combines structured, semi-structured, and unstructured questions to gather verifiable data from respondents.
8. Many educational research findings are documented for peer review before their presentation.

9. Educational research is interdisciplinary in nature because it draws from different fields and studies complex factual relations.

Educational research can be broadly categorized into 3 which are descriptive research, correlational research, and experimental research. Each of these has distinct and overlapping features.

Descriptive Educational Research

In this type of educational research, the researcher merely seeks to collect data with regards to the status quo or present situation of things. The core of descriptive research lies in defining the state and characteristics of the research subject being understudied.

Because of its emphasis on the "what" of the situation, descriptive research can be termed an observational research method. In descriptive educational research, the researcher makes use of quantitative research methods including surveys and questionnaires to gather the required data.

Typically, descriptive educational research is the first step in solving a specific problem. Here are a few examples of descriptive research:

- A reading program to help you understand student literacy levels.
- A study of students' classroom performance.
- Research to gather data on students' interests and preferences.

From these examples, you would notice that the researcher does not need to create a simulation of the natural environment of the research subjects; rather, he or she observes them as they engage in their routines. Also, the researcher is not concerned with creating a causal relationship between the research variables.

Correlational Educational Research

This is a type of educational research that seeks insights into the statistical relationship between two research variables. In correlational research, the researcher studies two variables intending to establish a connection between them.

Correlational research can be positive, negative, or non-existent. Positive correlation occurs when an increase in variable A leads to an increase in variable B, while negative correlation occurs when an increase in variable A results in a decrease in variable B.

When a change in any of the variables does not trigger a succeeding change in the other, then the correlation is non-existent. Also, in correlational educational research, the research does not need to alter the natural environment of the variables; that is, there is no need for external conditioning.

Examples of educational correlational research include:

- Research to discover the relationship between students' behaviors and classroom performance.
- A study into the relationship between students' social skills and their learning behaviors.

Experimental Educational Research

Experimental educational research is a research approach that seeks to establish the causal relationship between two variables in the research environment. It adopts quantitative research methods in order to determine the cause and effect in terms of the research variables being studied.

Experimental educational research typically involves two groups – the control group and the experimental group. The researcher introduces some changes to the experimental group such as a change in environment or a catalyst, while the control group is left in its natural state.

The introduction of these catalysts allows the researcher to determine the causative factor(s) in the experiment. At the core of experimental educational research lies the formulation of a hypothesis and so, the overall research design relies on statistical analysis to approve or disprove this hypothesis.

Examples of Experimental Educational Research

- A study to determine the best teaching and learning methods in a school.
- A study to understand how extracurricular activities affect the learning process.

Based on functionality, educational research can be classified into fundamental research, applied research, and action research. The primary purpose of fundamental research is to provide insights into the research variables; that is, to gain more knowledge. Fundamental research does not solve any specific problems.

Just as the name suggests, applied research is a research approach that seeks to solve specific problems. Findings from applied research are useful in solving practical challenges in the educational sector such as improving teaching methods, modifying learning curricula, and simplifying pedagogy.

Action research is tailored to solve immediate problems that are specific to a context such as educational challenges in a local primary school. The goal of action research is to proffer solutions that work in this context and to solve general or universal challenges in the educational sector.

Importance of Educational Research

1. Educational research plays a crucial role in knowledge advancement across different fields of study.
2. It provides answers to practical educational challenges using scientific methods.
3. Findings from educational research; especially applied research, are instrumental in policy reformulation.
4. For the researcher and other parties involved in this research approach, educational research improves learning, knowledge, skills, and understanding.
5. Educational research improves teaching and learning methods by empowering you with data to help you teach and lead more strategically and effectively.
6. Educational research helps students apply their knowledge to practical situations.

Educational Research Methods

- Surveys/Questionnaires

A survey is a research method that is used to collect data from a predetermined audience about a specific research context. It usually consists of a set of standardized questions that help you to gain insights into the experiences, thoughts, and behaviors of the audience.

Surveys can be administered physically using paper forms, face-to-face conversations, telephone conversations, or online forms. Online forms are easier to administer because they help you to collect accurate data and to also reach a larger sample size. Creating your online survey on data-gathering platforms like Formplus allows you to.also analyze survey respondent's data easily.

In order to gather accurate data via your survey, you must first identify the research context and the research subjects that would make up your data sample size. Next, you need to choose an online survey tool like Formplus to help you create and administer your survey with little or no hassles.

- Interviews

An interview is a qualitative data collection method that helps you to gather information from respondents by asking questions in a conversation. It is typically a face-to-face conversation with the research subjects in order to gather insights that will prove useful to the specific research context.

Interviews can be structured, semi-structured, or unstructured. A structured interview is a type of interview that follows a premeditated sequence; that is, it makes use of a set of standardized questions to gather information from the research subjects.

An unstructured interview is a type of interview that is fluid; that is, it is non-directive. During a structured interview, the researcher does not make use of a set of predetermined questions rather, he or she spontaneously asks questions to gather relevant data from the respondents.

A semi-structured interview is the mid-point between structured and unstructured interviews. Here, the researcher makes use of a set of standardized questions yet, he or she still makes inquiries outside these premeditated questions as dedicated by the flow of the conversations in the research context.

Data from Interviews can be collected using audio recorders, digital cameras, surveys, and questionnaires.

- Observation

Observation is a method of data collection that entails systematically selecting, watching, listening, reading, touching, and recording behaviors and characteristics of living beings, objects, or phenomena. In the classroom, teachers can adopt this method to understand students' behaviors in different contexts.

Observation can be qualitative or quantitative in approach. In quantitative observation, the researcher aims at collecting statistical information from respondents and in qualitative information, the researcher aims at collecting qualitative data from respondents.

Qualitative observation can further be classified into participant or non-participant observation. In participant observation, the researcher becomes a part of the research environment and interacts with the research subjects to gather info about their behaviors. In non-participant observation, the researcher does not actively take part in the research environment; that is, he or she is a passive observer.