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PHI304

Philosophy of SCIENCE AND TECHNOLOGY

Course Manual

ODL Edition

Professor Dipo Irele

Philosophy of Science and Technology

PHI304

University of Ibadan Distance Learning Centre
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Vice-Chancellor's Message

The Distance Learning Centre is building on a solid tradition of over two decades of service in the provision of External Studies Programme and now Distance Learning Education in Nigeria and beyond. The Distance Learning mode to which we are committed is providing access to many deserving Nigerians in having access to higher education especially those who by the nature of their engagement do not have the luxury of full time education. Recently, it is contributing in no small measure to providing places for teeming Nigerian youths who for one reason or the other could not get admission into the conventional universities.

These course materials have been written by writers specially trained in ODL course delivery. The writers have made great efforts to provide up to date information, knowledge and skills in the different disciplines and ensure that the materials are user-friendly.

In addition to provision of course materials in print and e-format, a lot of Information Technology input has also gone into the deployment of course materials. Most of them can be downloaded from the DLC website and are available in audio format which you can also download into your mobile phones, IPod, MP3 among other devices to allow you listen to the audio study sessions. Some of the study session materials have been scripted and are being broadcast on the university's Diamond Radio FM 101.1, while others have been delivered and captured in audio-visual format in a classroom environment for use by our students. Detailed information on availability and access is available on the website. We will continue in our efforts to provide and review course materials for our courses.

However, for you to take advantage of these formats, you will need to improve on your I.T. skills and develop requisite distance learning Culture. It is well known that, for efficient and effective provision of Distance learning education, availability of appropriate and relevant course materials is a *sine qua non*. So also, is the availability of multiple plat form for the convenience of our students. It is in fulfillment of this, that series of course materials are being written to enable our students study at their own pace and convenience.

It is our hope that you will put these course materials to the best use.

Prof. Isaac Adewole

Vice-Chancellor

Foreword

As part of its vision of providing education for "Liberty and Development" for Nigerians and the International Community, the University of Ibadan, Distance Learning Centre has recently embarked on a vigorous repositioning agenda which aimed at embracing a holistic and all encompassing approach to the delivery of its Open Distance Learning (ODL) programmes. Thus we are committed to global best practices in distance learning provision. Apart from providing an efficient administrative and academic support for our students, we are committed to providing educational resource materials for the use of our students. We are convinced that, without an up-to-date, learner-friendly and distance learning compliant course materials, there cannot be any basis to lay claim to being a provider of distance learning education. Indeed, availability of appropriate course materials in multiple formats is the hub of any distance learning provision worldwide.

In view of the above, we are vigorously pursuing as a matter of priority, the provision of credible, learner-friendly and interactive course materials for all our courses. We commissioned the authoring of, and review of course materials to teams of experts and their outputs were subjected to rigorous peer review to ensure standard. The approach not only emphasizes cognitive knowledge, but also skills and humane values which are at the core of education, even in an ICT age.

The development of the materials which is on-going also had input from experienced editors and illustrators who have ensured that they are accurate, current and learner-friendly. They are specially written with distance learners in mind. This is very important because, distance learning involves non-residential students who can often feel isolated from the community of learners.

It is important to note that, for a distance learner to excel there is the need to source and read relevant materials apart from this course material. Therefore, adequate supplementary reading materials as well as other information sources are suggested in the course materials.

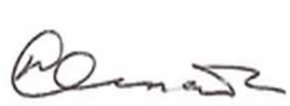
Apart from the responsibility for you to read this course material with others, you are also advised to seek assistance from your course facilitators especially academic advisors during your study even before the interactive session which is by design for revision. Your academic advisors will assist you using convenient technology including Google Hang Out, You Tube, Talk Fusion, etc. but you have to take advantage of these. It is also going to be of immense advantage if you complete assignments as at when due so as to have necessary feedbacks as a guide.

The implication of the above is that, a distance learner has a responsibility to develop requisite distance learning culture which includes diligent and disciplined self-study, seeking available administrative and academic support and acquisition of basic information technology skills. This is why you are encouraged to develop your computer skills by availing yourself the opportunity of training that the Centre's provide and put these into use.

In conclusion, it is envisaged that the course materials would also be useful for the regular students of tertiary institutions in Nigeria who are faced with a dearth of high quality textbooks. We are therefore, delighted to present these titles to both our distance learning students and the university’s regular students. We are confident that the materials will be an invaluable resource to all.

We would like to thank all our authors, reviewers and production staff for the high quality of work.

Best wishes.



Professor BayoOkunade

Director

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Contents

About this course manual

Philosophy of Science and TechnologyPHI304 has been produced by University of Ibadan Distance Learning Centre. All course manuals produced by University of Ibadan Distance Learning Centreare structured in the same way, as outlined below.

How this course manual is structured

The course overview

The course overview gives you a general introduction to the course. Information contained in the course overview will help you determine:

- If the course is suitable for you.
- What you will already need to know.
- What you can expect from the course.
- How much time you will need to invest to complete the course.

The overview also provides guidance on:

- Study skills.
- Where to get help.
- Course assignments and assessments.
- Margin icons.

We strongly recommend that you read the overview *carefully* before starting your study.

The course content

The course is broken down into Study Sessions. Each Study Session comprises:

- An introduction to the Study Session content.
- Study Sessionoutcomes.
- Core content of the Study Sessionwith a variety of learning activities.
- A Study Session summary.
- Assignments and/or assessments, as applicable.
- Bibliography

Your comments

After completing Philosophy of Science and Technology we would appreciate it if you would take a few moments to give us your feedback on any aspect of this course. Your feedback might include comments on:

- Course content and structure.
- Course reading materials and resources.
- Course assignments.
- Course assessments.
- Course duration.
- Course support (assigned tutors, technical help, etc.)

Your constructive feedback will help us to improve and enhance this course.

CourseOverview

Welcome to Philosophy of Science and TechnologyPHI304

The fundamental objective of this course is to introduce you, as a student of philosophy, to the general nature of science and technology, and to generate an understanding of the intrinsic issues in science and technology. We shall look at what distinguishes science from non science.The course is unique because it does not only give an understanding of the nature of philosophy as it applies to science and technology; it also serves as the foundation for the development of those core skills — especially critical thinking, conceptualization, analytic prowess and sound judgment — which are essential for the development of science and technology.

Notably, science and technology have become the makers of civilization in the contemporary world. These remarkable achievements have led some people viewing of science as *the dominant cognitive paradigm* or model of knowledge. This is clear from attempts to ground other areas of knowledge on scientific foundations and apparent certainty. By holding that whatsoever cannot be proved scientifically cannot be known, some people have argued that science is the only route to knowledge. Can this be true?

Course outcomes

Outcomes

Upon completion of Philosophy of Science and TechnologyPHI304 you will be able to:

- *differentiate* between science and pseudo-science.
- *analyse* the principle of inductivism.
- *discuss* the notion of conjecture and refutation in science.
- *discuss*the relationship between science and technology.
- *differentiate* between technology as a techne and as a practice.
- *point out* the impacts of technology.

Timeframe

How long?

This is a 15 week course. It requires a formal study time of 45 hours. The formal study times are scheduled around online discussions / chats with your course facilitator / academic advisor to facilitate your learning. Kindly see course calendar on your course website for scheduled dates. You will still require independent/personal study time particularly in studying your course materials.

How to be successful in this course

As an open and distance learner your approach to learning will be different to that from your school days, where you had onsite education. You will now choose what you want to study, you will have professional and/or personal motivation for doing so and you will most likely be fitting your study activities around other professional or domestic responsibilities.

Essentially you will be taking control of your learning environment. As a consequence, you will need to consider performance issues related to time management, goal setting, stress management, etc. Perhaps you will also need to reacquaint yourself in areas such as essay planning, coping with exams and using the web as a learning resource.

We recommend that you take time now—before starting your self-study—to familiarize yourself with these issues. There are a number of excellent resources on the web. A few suggested links are:

- http://www.dlc.ui.edu.ng/resources/studyskill.pdf

  This is a resource of the UIDLC pilot course module. You will find sections on building study skills, time scheduling, basic concentration techniques, control of the study environment, note taking, how to read essays for analysis and memory skills ("remembering").

- http://www.ivywise.com/newsletter_march13_how_to_self_study.html

  This site provides how to master self-studying, with bias to emerging technologies.

- http://www.howtostudy.org/resources.php

  Another "How to study" web site with useful links to time management, efficient reading, questioning/listening/observing skills, getting the most out of doing ("hands-on" learning), memory building, tips for staying motivated, developing a learning plan.

The above links are our suggestions to start you on your way. At the time of writing these web links were active. If you want to look for more, go to www.google.com and type "self-study basics", "self-study tips", "self-study skills" or similar phrases.

Need help?

Help

As earlier noted, this course manual complements and supplements PHI304at UI Mobile Class as an online course, which is domiciled at www.dlc.ui.edu.ng/mc.

You may contact any of the following units for information, learning resources and library services.

Distance Learning Centre (DLC)
University of Ibadan, Nigeria
Tel: (+234) 08077593551 – 55
(Student Support Officers)
Email: ssu@dlc.ui.edu.ng

Head Office
Morohundiya Complex, Ibadan-Ilorin Expressway, Idi-Ose, Ibadan.

Information Centre
20 Awolowo Road, Bodija, Ibadan.

Lagos Office
Speedwriting House, No. 16 Ajanaku Street, Off Salvation Bus Stop, Awuse Estate, Opebi, Ikeja, Lagos.

For technical issues (computer problems, web access, and etcetera), please visit: www.learnersupport.dlc.ui.edu.ng for live support; or send mail to webmaster@dlc.ui.edu.ng.

Academic Support

Help

A course facilitator is commissioned for this course. You have also been assigned an academic advisor to provide learning support. The contacts of your course facilitator and academic advisor for this course are available at the course website: www.dlc.ui.edu.ng/mc

Activities

Activities

This manual features “Activities,” which may present material that is NOT extensively covered in the Study Sessions. When completing these activities, you will demonstrate your understanding of basic material (by answering questions) before you learn more advanced concepts. You will be provided with answers to every activity question. Therefore, your emphasis when working the activities should be on understanding your answers. It is more important that you understand why every answer is correct.

Assessments

Assessments

There are three basic forms of assessment in this course: in-text questions (ITQs) and self assessment questions (SAQs), and tutor marked assessment (TMAs). This manual is essentially filled with ITQs and SAQs. Feedbacks to the ITQs are placed immediately after the questions, while the feedbacks to SAQs are at the back of manual. You will receive your TMAs as part of online class activities at the UI Mobile Class. Feedbacks to TMAs will be provided by your tutor in not more than 2 weeks expected duration.

Schedule dates for submitting assignments and engaging in course / class activities is available on the course website. Kindly visit your course website often for updates.

Bibliography

Reading

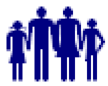
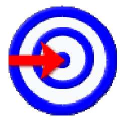
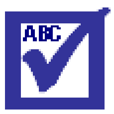
For those interested in learning more on this subject, we provide you with a list of additional resources at the end of this course manual; these may be books, articles or websites.

Getting around this course manual

Margin icons

While working through this course manual you will notice the frequent use of margin icons. These icons serve to “signpost” a particular piece of text, a new task or change in activity; they have been included to help you to find your way around this course manual.

A complete icon set is shown below. We suggest that you familiarize yourself with the icons and their meaning before starting your study.

 Activity	 Assessment	 Assignment	 Case study
 Discussion	 Group Activity	 Help	 Outcomes
 Note	 Reflection	 Reading	 Study skills
 Summary	 Terminology	 Time	 Tip

Study Session 1

The Nature of Science and Pseudo-Science

Introduction

In this Study Session, we will learn about the nature of science. We will also discuss the differences between science and pseudo-science.

Learning Outcomes

Outcomes

When you have studied this session, you should be able to:

1.1 *define* and *use* correctly the term "science".

1.2 *differentiate* between science and pseudo-science.

1.1 Meaning of Science

Tip

- Science as a discipline includes every aspect of human knowledge which has an empirical, observatory, experiential and experimental methodology.
- Science as a knowledge paradigm has a scope which envelopes such subjects as physics, chemistry, (micro) biology, zoology, botany.
- Science is the intellectual, systematic body of knowledge and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment.

Given the achievements and progress of the natural sciences, the status of the word **'science'** is now like a stamp of approval or guarantee of quality to which other disciplines, practices, and even advertising agents appeal in order to gain recognition, deceive naive people or sell products. Some practices that have been described as scientific include acupuncture (the belief that normal energy balance can be restored to relieve pain and cure other disorders in a person through inserting needles into different parts of the body), astrology (the belief that celestial bodies such as the sun. moon, stars and planets determine our characters at the time of our birth), crystology (the belief that crystals contain magical healing powers), phenology (the belief that one's character and mental capability are determined by the structure of one's skull), among several others. Are these beliefs scientific**?**

It would be foolish to completely reject these practices as unscientific if it can be shown that they are efficacious in alienating people's pain. That is, if several people claim to receive relief from acupuncture, it would be rational from a pragmatic point of view toaccept acupuncture as a form of medicine even if we cannot understand how or why it works. The implication here is that keeping an open mind towards some of these beliefs helps us to determine whether truth is contained in them or not. That said, if some of these beliefs truly work then it will be rational to find out why. In doing this, there will be need to formulate hypotheses and conduct controlled experiments to test them. Are these people willing to subject their beliefs to scientific tests? Only a few are willing, others merely state that their beliefs are scientific.

1.2 Differences between Science and Pseudo-Science

Pseudo-science A collection of beliefs or practices mistakenly regarded as being based on scientific method..

Since claiming that a belief is scientific (without experiment) does not mean that it is truly scientific, what criteria must we adopt to differentiate genuine science from fake or **pseudo-science**?

The first is that observation is key to scientific progress. Meticulous observations lead to a formulation of hypothesis. The history of science illustrates this. Galileo’s ability to confirm Copernicus’ statement that Venus varies in size was made possible by telescope. This means that technology can broaden our powers of observation and enable us to experiment on new ideas.

Another point is that reflective imagination and ability to think properly play vital roles in developing new scientific ideas. This is clear in the history of science where scientists have used their imagination to discover new scientific ideas. Mathematics is also important in the development of scientific ideas.

Science is also counter-intuitivein nature in that they go against common sense. Despite the fact that we now take the earth to be rotating, when you think about it, it is difficult to believe that the earth is spinning at 1,000miles per hour.

Note

- Observation is key to scientific progress.
- Reflective imagination and ability to think properly play vital roles in developing new scientific ideas
- Science is counter-intuitivein nature in that they go against common sense.

A discipline that does not claim to be scientific cannot be described as pseudo-science. For instance, since literary criticism does not claim scientificity, it cannot be described as a pseudo science: and as a way of deducing the sense in a text it is valid in its own right. The difference between pseudo-science and science is that pseudo-science claims to be scientific, but lacks the essence of science or to put it in another way:

"what distinguishes a pseudo-science is that it claims the status of science while lacking its substance”

○ ITQ Arabic and Islamic Studies is an academic discipline being studied in the University but does not claim to be a science. Should it then be termed as a pseudo-science? Why not, if not?

● ITA No. Arabic and Islamic Studies should not be termed as a pseudo-science. This is because it never claimed to be scientific in the first instance, and also because it lacks the essence of science.

One of the major differences between science and pseudo-science is that scientific hypotheses are testable. Pseudo-scientific hypotheses protect themselves from being testable because of their (1) **vagueness**, and (2) **Ad hoc exceptions**.

1. *It is unfeasible to verify or falsify a statement that is very vague*. The claim that 'quartz crystals can restore the balance and energy of your life' is vague and meaningless. And for it to be turned into a genuine scientific claim, it would require some form of measurable criteria to determine the meaning of words as 'balance' and 'energy'.
2. *When ad hoc exceptions are constantly made in relation to a hypothesis, such hypothesis cannot be scientifically tested.* For instance if, because you present a counter-example of a black swan, someone changed the original statement that 'all swans are white' into 'all swans are white except that mutation', then you will discover that you are unable to test such hypothesis. A genuine scientific hypothesis is general in nature in that it does not make ad hoc exceptions in the face of counter-examples.

Therefore, it follows that a hypothesis is scientifically genuine if it is testable, clear in predictions and avoid ad hoc exceptions. Thus, we can say that statements as 'unlike magnetic poles attract each other', 'acids turn litmus paper red', are scientifically testable and genuine;while statements as 'it always rains on Tuesdays; 'strong men don't cry; ¯you may or may not win the lottery in 2012', etc. are not.

Study Session Summary

Summary

In this Study Session,you learnt that science is a paradigm of knowledge and as a paradigm of knowledge; science is empirical, observatory, experiential and experimental in methodology. We explained that scientific disciplines are characterized by the principle of testifiability, verifiability, falsifiability, clarity in prediction and generality in scope.

Assessment

Assessment

SAQ 1.1 (tests Learning Outcome 1.1)
Can you list the characteristics of science as a discipline?

SAQ 1.2 (tests Learning Outcome 1.2)
What do you think distinguishes science from pseudo-science?

Study Session 2

The Scientific Method

Introduction

In this Study Session, we will explore the notion of methodology as it applies to science.

Learning Outcomes

Outcomes

When you have studied this session, you should be able to:

2.1 *explain* scientific methodology.
2.2 *analyse* the principle of inductivism.
2.3 *discuss*the problems associated with observation and hypothesis.
2.4 *highlight* the practical and theoretical problems of induction.

2.1 The Notion of Methodology

Methodology The notion of methodology implies the procedure by which endeavour of human knowledge is organised or carried out towards attaining its inherent knowledge and realizing its targeted objective.

ObservationWatching the behaviour of a model.

HypothesisThe preliminary assumption or tentative explanation that accounts for a set of facts, taken to be true for the purpose of investigation and testing; a theory.

TheoryAn assumption, accepted principles, and rules of procedure based on limited information, devised to analyze, predict, or otherwise explain the nature or behaviour of a specified set of phenomena.

The notion of **methodology** implies the manner or particular procedure by which research activities in an academic discipline or an endeavour of human knowledge is organized, or put together, towards attaining its inherent knowledge and realizing its targeted objective. Just as you talk about the structure or architectural design of an edifice to depict the way the different parts that make up the edifice have been structured together; so we talk of the methodology of an academic discipline to imply the manner in which the facts, information, concepts and principles that make up the discipline have been put structured, most times with the application of suitable theories. The methodology of one academic discipline may and is usually different from another. In some disciplines, certain concepts or theories should be mastered first before others can be understood; while in others several distinct concepts or theories can be acquired at the same time.

2.1.1 Scientific Methodology

The notion of methodology, as it applies to science, portrays the whole manner in scientific activities are carried out, or, better still, how the scientist carries out his academic activities. The scientist observed (see **observation**) certain phenomenon and he or she would have seen a pattern and based on this he or she would formulate a **hypothesis**. From this he or she would make a prediction, and this prediction is subjected to **experiment**. If this prediction is confirmed over and over again, and if it is positive, then there would be a **law**. The law is cast hypothetically, that is, in such a way that if certain conditions are obtainable then such and such would happen. In other words, there is a covering law which predicts the phenomenon in question when certain conditions are obtainable. In the final analysis a **theory** would then be formulated which explains the law in a proper way. In other words, this theory allows other people to repeat or perform the same experiment in order to confirm the result or confirm the theory. This adds objectivity to the theory. Therefore there is no rigid demarcation between theory and law.

Tip

Objectivity in science connotes the attainment of scientific knowledge that is devoid of and extends beyond socio-cultural group prejudice. It implies adducing an evidence in support of a knowledge claim, such that will make sufficient warrant for the claim so that it becomes reasonable to accept the claim, attribute it to the status of knowledge.

2.2 Principle of Inductivism

The principle of inductivism is as follows:

Theories imply predictions or generalizations which are basic sentences, what are usually known as observation sentences. If any of these predictions are false, then the theory is falsified; if sufficiently many of these predictions are true, then the theory is confirmed.

The process of falsification is the deduction of predictions or generalizations from the theory which are false based on the outcome of experiment. However, the testing or experimenting of hypothesis can also corroborates the hypothesis which implies that a hypothesis has been subjected to severe tests or experiments and has withstood them.

Thus the principle of inductivism is the way science develops. Initially science consists of empirical simplification formulated through observation. Later, as the scientific process advances, theoretical terms or hypothesis are introduced and subjected to experiment from which theoretical laws or generalizations are formulated. Therefore, the principle of inductivism indicates the scientific procedure corresponds to the way in which we obtain knowledge about physical states by our observations.

Note

Certain steps are worth noting:

1. Observation
2. Hypothesis
3. Experiment
4. Law
5. Theory

2.3 Problems Associated with Observation and Hypothesis

2.3.1 The Problems with Observation

The problems with observation are those of relevance, expectations, expert seeing and the observer effect.

Relevance: In observing or investigating a problem, we usually begin with what we think are relevant to the problem and discard others as irrelevant. In doing this, there is a danger of overlooking a relevant idea as irrelevant, and which could turn out to considerably affect the outcome of our observation.

Expectation: The problem here is that our anticipation can influence what we observe. Isaac Newton's law had predicted that mercury was deviating from its orbit. In explaining this anomaly, some astronomers in the 19th century claimed that the deviation was caused by a yet to be discovered planet named Vulcan. This belief led several astronomers to claim that they have observed Vulcan. But it turned out that Vulcan does not exist. The plausible explanation for mercury's deviation was not known until Einstein propounded his theory of relativity.

Expert Seeing: Using scientific equipment such as microscopes and telescopes in observation can complicate things and result in error judgments for two reasons. One reason is that it takes a lot of practice before one could master the use of these equipments. The other reason is the nature of the equipment itself. For instance, the telescope Galileo used in discovering the phases of Venus and the moons of Jupiter was quite crude. As a result, Galileo inaccurately drew the moon to include some craters and mountains that do not actually exist.

The Observer Effect: This point is that the act of observation can sometimes affect what we observe. This point is that the instruments or tools that are used in scientific experiments affect t what we observe and as such affect the result. Notwithstanding this, this problem cannot be exaggerated because the strength of science lies in the fact that it is communal and self correcting. This implies that the scientific community corrects itself overtime and any error in science is detected by scientists.

2.3.2Problems Associated with Testing of Hypothesis

There are some difficulties associated with the scientific method of testing hypotheses. These include confirmation bias and background assumptions.

Confirmation Bias: This occurs when scientists look for evidence that supports their beliefs and ignore those that contradict them. Hypotheses that contradict ones favoured hypotheses should not be overlooked. In fact, a good and thorough going scientist is one that looks for evidences that may falsify his hypotheses and seek to redress them.

Since most scientists enter the lab with an expectation there is the tendency to dismiss results that contradict their expectation as 'experimental' or 'human error'. To be on the safe side it would be rational for scientists to take observation that contradicts their own seriously.

Scientists are becoming increasingly aware of confirmation bias. For example, even though Gregor Mendel's (1822-84) research on the heredity traits of peas laid the foundation for modern genetics, some modern geneticists (given Mendel's all-positive results) have accused him of only reporting evidences that confirmed his hypotheses.

Background Assumption: Several background assumptions are usually made when testing hypotheses, although they could turn out to be wrong. For instance, people of Copernicus' time believed that the fixed stars are relatively close to the earth. This means that the position of nearby stars relative to distant ones ought to change when the earth is orbiting the sun. This change in relative position is called parallax. This phenomenon can be made clearer with the following analogy. Hold and object (e.g. a pencil) out in front of you in a way that it exactly covers another distant object (e.g. a tree), and close each of your eyes in succession. You will discover the pencil's position in relation to the tree appears to change. Similarly, it is expected that if truly the earth rotates, the stars' relative position should alter when the earth is moving. No one, not even Copernicus or Galileo, was able to observe the required parallax to solve this problem. In the end, it turned out that the assumption of the relative closeness of the fixed stars to the earth was in error, "and in the 19th century the stellar parallax was finally observed."In addition to confirmation bias and background assumption, dissimilar hypotheses can be consistent with a given set of data.

2.4 Problems of Induction

2.4.1 Practical Problems of Induction

The problem here is on the question of how many observations must be made before we can generalize. It would be reasonable to draw such conclusions from several observations rather than from insufficient ones because the more our observations support our hypotheses, the more confident we will be in believing it.

There is still trouble because some well-confirmed generalizations have turned out to be false. For example, from several particular observations, Europeans held the belief that "all swans are white" up until the 18th century when some black swans were found in Australia. Similarly, several experiments confirmed the plausibility of Newtonian physics for two and a half centuries. However, Einstein came up with an alternative theory which proves that Newton's laws were not the most excellent description of physical reality. The point here is that even well-confirmed hypotheses can in the end turn out to be false.

Even though we have only observed just a minute fraction of the universe we (on the basis of this) ambitiously claim to have discovered laws of physics that apply to all times and all places.

The above might lead one to call for humility on scientists' part in making ambitious claims. That is, instead of claiming that "all metals expand when heated," scientists should modestly claim that "all observed metals expand when heated." Although this indicates good sense of humility, the fact remains that most physicists believe that they are discovering general laws according to which the universe is to be explained.

2.4.2 Theoretical Problems of Induction

This problem concerns the fact that science is an empirical discipline in that it claims nothing beyond what has been observed. In fact, what is supposed to distinguish science from pseudo-science is the fact that it is grounded in observation, and this is threatened by the principle of induction. There are three very costly ways of going about this problem. One way is to take seriously the empiricist label of science and avoid making claims about unobserved entities. The price here is that we must discard any attempt or claim of discovering laws of nature that apply in all times and all places. Another way is to defend scientists' use of the inductive principle and pay the price of abandoning the claim that science is generally empirical. A third approach is to simply overlook the problem and just continue with the scientific enterprise.[3]

2.4.3 Karl Popper's Principle of Falsification

One thinker who considered the problem of induction a serious threat and attempted to resolve it was the philosopher of science, Karl Popper (1902-94). Popper's aim was to distinguish genuine science (e.g. Einstein's theory of relativity) from what struck him as pseudo-science (e.g. Marxism and psycho-analysis).

Popper was originally impressed by theories which sort to explain everything as propounded by such great minds as Karl Marx (1818-83), Sigmund Freud (1856-1939) and Alfred Adler (1870-1937). For instance, Adler's theory states that human beings are controlled by their feelings of inferiority According to him, "to be human means to feel inferior." Adler believed every human behaviour can be explained by this principle. Popper is of the view that the supposed strength or ability of this theory in explaining everything is its very weakness.

To illustrate this consider a situation where a man sees a child being washed away by a fast-flowing river. This man can either jump into the river to save the child or he does nothing. In doing the former, Adler would say the man demonstrates bravery in trying to overcome his feeling of inferiority. If he chooses to do the latter, again Adler would say the man is clearly suffering from inferiority complex which he cannot overcome. That is to say, the situation cannot be proved one way or the other.

Scientifically, "a theory that tries to explain everything ends up explaining nothing". And as Popper sees it, a genuine scientific theory differs from such theories which put itself in danger. For instance, certain predictions were made on the basis of Einstein's general theory of relativity which were tested and confirmed in 1919. You can besure that scientists would have rejected this theory if those observations had not confirmed it.

○ ITQ — What repressed Karl Popper about the inductionist principle such that he considered it a serious threat to science and thus postulated the falsificationist principle.

● ITA — The fact that he tried to explain everything by generalizing from particular cases which may be insufficient and from there trying to apply it to all cases.

Conjectures and Refutations

In resolving the challenge posed by the principle of induction, Popper came up with the principle of **conjectures** and **refutations**. A conjecture means an intellectual imaginative leap which can be subjected to test. That is, it is an imaginative hypothesis that is testable. According to Popper, good hypotheses are not just generalized on the basis of observationaldata: rather they are often generated via imagination, which makes one to see things from different perspectives.

Copernicus followed this principle when he stated that the earth revolves round the sun and not the other way round. According to the author, scientists usually get their best ideas intuitively. For instance, Newton discovered his idea of universal gravity by seeing an apple fall from a tree, while Mendeleyev was said to have discovered his idea for the periodic table through a dream. The point here is that once these intuitions are received and pondered upon, conjectures or imaginative hypotheses are formulated, and these are later subjected to test.

The most important feature of genuine scientific conjectures is the fact that they can be tested. But how does this solve the problem of induction? This is where 'refutations' comes in. In resolving this problem, Popper noted the irregular relation that exists between confirmation and falsification. This is that while innumerable confirmations cannot guarantee our certainty about a given law, just one counter-example is enough to falsify it. For instance, no matter how many confirming observations we make in regard to the law, that "all metals expand when heated', we cannot be certain that the law is true because there is always the possibility that the next metal we heat may not expand. However, our certainty that the law is false can be guaranteed by just one counter example a metal that fails to expand when heated. Thus, while confirmation only proves a law tentatively, refutation only requires one counter example to decisively prove the falsity of a law.

From this, Popper concludes that scientists would simply waste precious time in attempting to prove the plausibility of their hypotheses since this is impossible given the problem of induction. A better option, though strange, is for scientists to spend time proving that their hypotheses are false. On this proposal, Popper believed science will progress because people will be able to overcome scientific dogmatism by questioning orthodox scientific knowledge.

The rationale of this principle is not to spend time falsifying such absurd hypotheses as "real men do not cry", rather the idea is to re-examine well-confirmed and received hypotheses in order to determine their weaknesses. This point can be illustrated by the scientific law that water boils at 100 C. No conclusive prove that this law is true or meaningful contribution to science can be achieved if one merely continues to boil different pans of water. The best thing is to seek situations that contradict theclaim that water boils at 100°C. With this, one can discover that at high altitudes, water boils at less than 100°C. The task would now be that of explaining why water boils at a lower temperature at a higher altitude. In doing this, new ideas can be tested, and that this can lead to genuine scientific progress.

What Popper's idea reveals is that we should provisionally accept theories that resist falsification as our best for the moment. However, these theories cannot be absolutely true since there is always the possibility of a better theory replacing it as was the case with Newtonian physics.[7]

Reflection

Do you think the problem of induction amounts to time wastage for scientists in their quest to prove the plausibility of their hypothesis? Induction has limited values in the evaluation of scientific knowledge claims, but is this sufficient?

If yes, what is the alternative to this? Can the alternative be to re-examine well-confirmed and received hypotheses in order to determine their weaknesses?

Popper's theory has chiefly been criticized on the ground that it is conclusive in theory but not in practice. This criticism questions the decisiveness of falsification, that it is no more conclusive than confirmation. When someone performs an experiment that contradicts, for example, one of Newton's laws of motion, such a person cannot claim to have disproved Newton. Such a person only succeeded in messing up the experiment. This means that while just one contradictory example is enough to falsify law of nature in theory, the same is not enough in practice. We can do either of two things when our hypothesis clashes with our observation: reject either the hypothesis or the observation. The history of science shows that scientists seldom reject the former. Examples can be drawn from Physics (Newton), Chemistry (Mendeleyev) and Biology (Darwin) respectively.[8]

Physics One implication of Newton's theory of gravity is that, on the basis of the attractive forces among the stars, the universe is supposed to collapse. Even though Newton saw this as a huge setback, he did not dump his theory; rather he unscientifically argues that God must be counteracting gravity by keeping the stars in their places.

Chemistry By the time Dimitri Mendeleyev (1834-1907) proposed the idea of the periodic table by arranging elements according to their atomic weights, he discovered that some elements failed to match his model. Instead of abandoning his theory, Mendeleyev concluded that the anomaly must have been caused by experimental error.

Biology for Charles Darwin's (1809-82) theory of evolution to be plausible, it required the earth to be hundreds of millions of years old so that species have enough time to evolve. However, Lord Kelvin (1824-1907), the leading physicist of that time, calculated the earth as being no more than 100 million years old. Even though Kelvin's calculation was based on the best available knowledge at that time, Darwin rejected it as ridiculously inadequate, and upheld his theory.

Later scientific discoveries and explanations proved that those scientists were right for not abandoning their theories in the face of contradictory observations. The universe failed to collapse because the speed at which stars move away from each other counteracts gravity. The presence of various isotopes caused the anomaly in the weights of some of Mendeleyev's elements. Also, it was eventually discovered that Kelvin's method of calculating the earth's age was faulty.

What these instances show is that scientists should not be quick to abandon promising theories immediately they encounter counter-observations. This is because, in the end. These counter-observations may have resulted from experimental error or faulty background assumptions. Nevertheless, if counter-observations consistently contradict a theory, then abandoning it would be rational.

A perfect scientific theory is hard to come by, and that every area of science has anomalies and unresolved problems. Scientists believe that, with time, a well-established and successful theory will resolve certain outstanding problems. For instance, when scientists found out that the planet Uranus was acting contrary to the predictions of Newton's laws, they did not dump Newton's physics, rather they held that some yet to be discovered planet must be responsible. They upheld both the counter- observation and the theory, but proposed an auxiliary hypothesis— an unknown planet exists— to explain the anomaly. This auxiliary hypothesis led scientists to discover the planet Neptune in 1846. In the same vein, they postulated the existence of a planet (Vulcan) to resolve similar anomaly with mercury, but it turned out they were wrong. Newtonian physics could not explain this phenomenon.Consequently, a scientific revolution look place and Newtonian physics was replaced with the theory of relativity.

- ○ ITQ What is the criticism against Karl Popper’s intervention to the principle of induction?
- ● ITA Falsification principle is conclusive in theory but not in practice

2.4.4 Rationalist Strand in Scientific Thinking

From the just concluded section, it is clear that when observation conflict with hypothesis, the scientist has three options: (i) reject the hypothesis, (ii) reject the observation, and (iii) accept both the hypothesis and the observation and make an auxiliary hypothesis.

The choice of either of the first two suggests that science contains both rationalist and empiricist elements. While the rationalist takes reason as the basic source of knowledge, empiricists believe this source to be experience. Thus, when theory conflicts with observation, a rationalist is likely to favour a promising theory over a contradictory observation, while an empiricist is very likely to favour the observational or experimental evidence. There is no doubt that several great scientists (as we saw in the criticism of Popper) have exemplified rationalist tendencies in their refusal to abandon their theories in the face of contradictory observation.

Science derives its power from its ability of combining mathematical reason with observational experience. The rationalist element ofscience is contained in the belief that there is order in the universe, and that this order can be expressed in scientific theories. The empirical element is that a theory must be consistent with observational evidence if it is to survive.

Popper's theory makes it clear that we cannot conclusively verify or falsify scientific theories. Thisis because, in a case of contradiction, one can uphold the theory and reject the observation. The point here is that a middle ground (of conclusive verification and falsification) is required in making sense of scientific theories. That is, absolute certainty or proof is only necessary for mathematics and logic, and not for science.

Therefore, "in science, as in every other area of knowledge that applies to the world, we have to make do with something less than certainty.

○ ITQ Science comprises both rationalist and empiricist strands. Do you agree?

● ITA Your valid response is likely based on the following:

Rationalism proposes reasons which constitute rational processes for the evaluation of intellectual novelties or conceptual variants while the empiricist strand concerns the truth or falsity of a matter by describing conditions obtainable in the physical world.

Thus, the statement is true.

Discussion Activity

Is it rational to base science on inductive reasoning?

Post your response on Study Session Two forum page on course website.

Study Session Summary

Summary

In this Study Session,youlearnt that methodology of a discipline refers to how its content or subject matter is structured in order to attain its intended knowledge; the notion of scientific methodology presupposes the principle of inductivism, that is, a reasoning process which infers a general conclusion from particular observations.We notedinductivism implies five steps, namely: observation, hypothesis, experiment, law and theory. Lastly, we observed that the inductivist principle is not devoid of inadequacies.

Practical problems abound in inductivism, for example, the problem of insufficient observations or eventual falsification of some well-confirmed generalizations. We observed also that theoretical problems abound in inductivism due to the empirical nature of science and science's assertions of generalizations in all times and places.

Assessment

SAQ 2.1(tests learning outcome 2.1 and 2.2)

List the inherent principles you will take ininductivism.

Assessment

SAQ 2.2 (tests learning outcome 2.3 and 2.4)

Analyze the practical and theoretical problems in induction.

Study Session3

Kuhn and Scientific Revolution

Introduction

In this Study Session, we will examine Thomas Kuhn's paradigmatic approach to science.

Learning Outcomes

Outcomes

When you have studied this session, you should be able to:
3.1 *describe*normal science.
3.2*discuss* Thomas Kuhn's idea of paradigm shift or scientific revolution.
3.3 *discuss* scientific revolutions.

3.1 Normal Science

Normal ScienceA period when scientists are basically preoccupied with solving a problem within a paradigm without questioning the paradigm.

For Kuhn, **normal science** is a period when scientists are basically preoccupied with solving a problem within a paradigm without questioning the paradigm. In the earlier mentioned example, when scientists discovered that the orbit of Uranus contradicts Newton's law of mechanics, they did not abandon or question Newton's paradigm but they sort to resolve the problem within it and it paid off. Even though Popper might reject this approach as uncritical since (in his view) scientists must constantly question their assumptions, the fact remains that progress can hardly be achieved if scientists constantly question the assumptions within their operative paradigms. Thus, while great scientists as Newton, Dalton and Darwin constructed new paradigms, most scientists explicated the details of the paradigms by performing normal science within them, thereby extending the body of scientific knowledge.

Tip

Normal science is a prevailing paradigm in science such that it is the operational paradigm through which one attempts to do science without critically interrogating it or questioning its scientific and epistemic efficacy.

3.2 Kuhn's Paradigm Shift and Scientific Revolutions

Kuhn is of the opinion that, contrary to popular beliefs, the progress of science is not always smooth and stable as normal science makes it seem. According to him, science historically progresses by way of scientific revolutions. A scientific revolution occurs when scientists are dissatisfied with a given paradigm and come up with entirely new ways of resolving problems. Once this new approach succeeds, it becomes a new paradigm for normal science and replaces the old paradigm. Some examples of scientific revolutions are the replacement of the geocentric model with the heliocentric model of the universe, the replacement of Aristotelian physics by Newtonian mechanics in the 17th century as well as the replacement of Newtonian mechanics byEinstein's theory of relativity in the early part of the 20th century. Thus, science does not progress smoothly or linearly, rather its progress consists in **paradigm shifts** or displacements.

There is no perfect theory in science and science at any given time consists of unresolved puzzles. There is usually the belief among scientists that such puzzles can be solved in a paradigm during normal science. If, however, the number of unresolved anomalies cumulates into a critical mass, some are likely to start questioning the paradigm itself. A scientific revolution occurs when a new paradigm gives better explications of these anomalies. Surely, not everyone will shift or be converted into this new paradigm, and there are usually violent debates between adherents of the old and new paradigms. Most at times, the new paradigm gradually triumphs not so much because it is convincing, but because older and more conservative scientists die out and a new generation that is familiar with it grows up.

1 At times, one chooses to dissent from sentences or symbolic generalizations in one’s scientific community. Justify this in the light of your understanding of Thomas Kuhn’s notion of paradigm shift or scientific revolution.
2 Kuhn says that science historically progresses by way of scientific revolutions, since every scientific domain has limited validity and a scientific revolution occurs when scientists are dissatisfied with a given paradigm, critique it, discovers its inadequacies and come up with entirely new ways of resolving problems.

How Rational is Science?

As Kuhn sees it, the progress of science is not rational in that there is no common ground for deciding the rationality of sticking with an existing paradigm or shifting to a new one since (as stated earlier) no theory can be conclusively verified or falsified. This inconclusiveness is due to the fact that observations that tend to falsify an old paradigm can be dismissed as resulting from experimental error, or certain auxiliary hypotheses can be created to explain them. This lack of a rational way of preferring one paradigm over another led Kuhn to liken paradigm shift to a religious conversion with such actions being influenced by some unscientific factors like personal ambition and social pressure.

Kuhn's idea is plausible because the history of science shows that scientists are not solely motivated by the love of truth, but also by other factors such as ambition, vanity and enmity. Scientists engage in priority dispute over who first discovered a particular law or came up with a given theory. Also, they are humans and like other persons, they are interested in their social status and public recognition such as being awarded. For instance, the astronomer Edwin Hubble (1889-1953) showed his desperation forgetting the Noble Prize when he employed and expert in public relations to help him.

Unfortunately, Hubble's effort came to not as astronomy has no Noble Prize.

Social factors such as the military's desire for power, big business desire for profit as well as adequately funded areas of research play significant roles in the development of science as well as in determining scientists' choice of problems to resolve. Some scientists even prefer less controversial areas of research than some politically sensitive ones. In addition, their desire to get promoted puts them under the pressure of conforming to the beliefs and values of the paradigm they find themselves.

3.3Criticisms against Kuhn's Position

Some objections can be pressed against Kuhn's philosophy of science these are:

1) Most scientists in normal science do not question the paradigm within which they operate: instead they focus on puzzle solving.
2) The history of science indicates that science does not progress linearly, but by a series of revolutionary leaps.
3) There is no basically rational way of choosing between rival paradigms in times ofscientific crisis.

3.3.1Criticisms in Normal Science

Even though there is some truth in Kuhn's claim that normal scientists hardly question the paradigm within which they operate, it is not a good thing for them not to do so because their beliefs will end up being dogmatic. What we have to note is that scientists are not dogmatic but they question certain assumptions in their areas. Scientific community is one with a critical mind and the scientists probe deeply into any assumption in their areas, it is therefore not true that normal science is not a critical one.

Note

Normal science is critical in nature. This is because the science community is one with a critical mind and the scientists probe deeply into any assumption in their areas, even when operating within the sphere of normal science. In fact, it was resultant from the criticality inherent in normal science that scientific revolution is possible in the first instance.

3.3.2 Scientific Revolutions

Kuhn's accounts of the history of science in relation to revolutions dangerously suggest that our body of current scientific knowledge will someday be eroded by a new revolution. It is not completely true that older paradigms vanished without trace when replaced through paradigmatic revolution. The history of science shows that scientific knowledge is cumulative in nature and that science is edging closer to the truth by each passing day.

Rather than conceive new paradigms as displacing older paradigms without trace, new paradigms are more or less inclusive.For instance, notwithstanding its replacement with Einstein's theory of relativity. Newtonian mechanics is still valid in some important respects, and is a special case of the relativity theory. In the same vein, although Aristotelian physics was replaced by Newtonian physics, it reasonably explained certain everyday phenomena. While Newtonian physics can explain far more phenomena than Aristotle's physics. Einstein's relativity theory explains more phenomena than Newton's physics, especially the motion of electrons within an atom and the nature of a gravitational field near a black hole.

It is reasonable to see science as progressing cumulatively. This is because while it is possible for some well-confirmed theories to turn out to be wrong, it is difficult to think that future scientists will come up with counter theories that the earth does not orbit the sun, or that water does not consists of hydrogen and oxygen. Whatever new findings they may arrive at will be inclusive of the whole facts.

3.3.3 Choosing between Rival Paradigms

During periods of scientific crisis, Kuhn's position is that the scientists' choice of paradigm is not purely rational, but is influenced by unscientific elements as personal ambitions and social pressure. This is true to some extent, but it is necessary to view it from another angle by distinguishing between the origin of a belief and its justification. The origin of a belief is not of any importance in science, what is important is that the theory is testable; and if it is confirmed by experiment it is accepted but if it is not it is thrown out.

Kuhn's position is a form of relativism since he asserts that different paradigms interpret the world differently and their truth claim cannot be conclusively proved. Rather than see scientific knowledge as relative, we should consider it as judgmental. This is so because judgment is what scientists need in deciding, for instance, which anomalies to take seriously and which to dismiss as experimental error; which factors should be observed and which can be ignored without problem, among other things. Although these judgments could turn out to be wrong, it is not irrational to make them. That is, even though astronomers were wrong in postulating an undiscovered planet (Vulcan) as the reason of Mercury's irregular orbit, such hypothesis was rational given the success recorded by similar auxiliary hypotheses based on Newton's mechanics. The point here is that the fallibleness of reason does not mean that it is without value.

Science derives great strength from its self-correcting nature. Even though dogmatism might set in within a scientist's operational paradigm, the competitive nature of scientists ensures that their findings are cross-checked, and the better ones are accepted. It takes less time for genuine ideas to gain acceptance. For instance, while it took more than a hundred years for Copernicus' theory to be generally accepted, physicists accepted Einstein's theory in less than fifteen years. In the same vein, scientists usually weed out or reject theories whose results cannot be replicated by other scientists.

The point in all this is that even though there is no well-established criterion for choosing between varying paradigms, some theories as evidence proves them looks more plausible than others. It therefore follows that one would be justified in dismissing a theory as irrational beyond a certain time if it is an implausible one.

- ○ ITQ Is Kuhn's paradigmatic approach to science a form of relativism?

  Yes / No?

- ● ITA If you have chosen yes as answer, then you are correct. In fact, different paradigms interpret the world differently and judgementally such that their truth claim cannot be conclusively proved.

Science and Truth

This point has to be made:

> *"although people hold science in high esteem, it is clear that absolute proof does not exist in science and that hypotheses can never be conclusively verified or falsified".*

Nevertheless, this is not enough reason to embrace relativism. The way out, is that if the claims of a scientific theory are consistent with available evidence, and if such theory works in practice; then we should accept it as true for the moment. Although a better theory can (in the future) replace it, there is no other way of proceeding or edging closer to the truth.

What is of importance is that we must be critical of our scientific beliefs and be open to questioning scientific assumptions. Given the tendency of only taking note of evidence that confirms our hypotheses, it is rational to seek those which falsify them.

Discussion Activity

Knowing that hypothesis can never be conclusively verified or falsified, how will you describe the concept of truth as it applies to science.

Post your response on Study Session Three forum page on course website.

Study Session Summary

Summary

In this Study Session, you learnt that science is not static. We explained how paradigm shifts,and how revolutions occur in science. We noted also that no scientific theory is absolute. Finally, we listed the elements of relativism in Kuhn's account of science which necessarily requires criticality and inquiry.

Assessment

Assessment

SAQ 3.1 (tests Learning Outcomes 3.1 and 3.2)

Analyze the concept of normal science as it reflects in Thomas Kuhn's account of science.

SAQ 3.2 (tests Learning Outcome 3.2)

Describe the idea of paradigm shift or scientific revolution in Thomas Kuhn's account of science.

SAQ 3.3 (tests learning outcome 3.3)

Thomas Kuhn's account of paradigm shift allows for a choice between two rival paradigms. Discuss this in cognizance of his idea of scientific revolution.

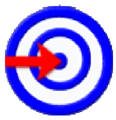
Study Session4

What is Technology?

Introduction

In this Study Session, we will examine technology. We will also explain the nuances in technology as a techne (technique), and as a practice.

Learning Outcomes



Outcomes

When you have studied this session, you should be able to:

4.1 *discuss* conceptual issues in the definition of technology.

4.2 *explain* the nuances in technology as a techne and as practice.

4.1Conceptual Issues in the Definition of Technology

Perhaps the most fundamental aspect of the philosophy of science and **technology** is getting clear on what technology really is. Philosophers and non-philosophers have defined it in various ways. By way of etymology, technology derives from the Greek word ‘**techne’**, which translates into ‘craft’ or ‘art’, “but can also be seen as a practice that is grounded in theoretical knowledge or ‘an account’, thus linking it closely to notions of expertise or know-how.This implies that it is from the ‘know-how’ that the craftsman can create a ‘craft’ or ‘art’. In other words, while craft basically refers to the finished product of an artisan (a major sense of contemporary conception of technology), techne refers to the knowledge by which the products were made. Thus, since techne is oriented towards the production of specific things, it is the case that the word ‘techne’ best translates as ‘technical knowledge’. In this sense it does not confuse such knowledge with products that were created as a result of it. In his Nicomachean Ethics, Aristotle tells us that “a techne is the same as a state involving true reason concerned with production’.

Greek thinkers believe that technology learns from or imitates nature. For instance, house-building came about by imitating how spiders build their nets. In his philosophy of nature (physis), Aristotle held that technology or art imitates nature in some cases, and even (in other cases) completes what nature cannot bring to finish. However, Aristotle held that a fundamental ontological difference exists between natural and artificial entities. The unity of forms and matter, which makes up natural entities, is self-generating, while those of artificial entities are not they are generated by outward causes of human aims. that is, ‘natural products (animals and their parts, plants, and the four elements) move, grow, change, and reproduce themselves by inner final causes; they are driven by purpose of nature. Artifacts, on the other hand, cannot reproduce themselves'.For instance, there is no way a wooden bed can reproduce itself.

4.2 Nuances in Technology as a Techne and as Practice

While ancient techne basically translates into technical knowledge and less into crafts or products, contemporary technology mostly refer to products such as instruments and machines. A computer, for instance, is a technology. The earliest uses of the word in contemporary time denote knowledge or systematic knowledge of the arts rather than the products of such knowledge. This seems to imply that there is little or no difference between techne and technology. This has divided contemporary interpreters of technology along quantitative and qualitative lines.

Quantitative interpreters of technology do not find any fundamental difference between techne and technology because, as they see it, contemporary technology is a consequence of the accumulated development of earlier, more primitive, technologies. An example of this quantitative argument can be found in anthropological claims regarding stone chip spears of flints of ancient humans as constituting foundations of more complicated contemporary technologies.

This point has been emphasized by some scholars. They argue that (technology has been going on since humans-harnessed fire, or dragged a stick across the ground to create a furrow for planting seeds, but today it exists to a degree unprecedented in history… furthermore, technology is evolving at an extra ordinary rate, with new technologies being created and existing technologies being improved and extended).

On the contrary, some other interpreters have argued that there are fundamental differences between techne and technology. They argue that while techne is limited in function, technology is characterized by its complete lack of limitation. It is also argued that whereas techne is defensive in nature, technology is offensive. Further it is argued that rather than simply creating something that would not have existed otherwise, as with techne, technology seeks to control nature as a whole.For these adherents, contemporary technology is not only more complicated or greater in scope and size than techne, and it is fundamentally different.

The foregoing implies that the idea that technology is an accumulated and steady development of techne must be abandoned. This point is in line with Thomas Kuhn's idea of scientific revolution in which a new scientific paradigm replaces and displaces older paradigm(s) without trace.

These disagreements among interpreters notwithstanding, two definitions of technology are clear from the above: Technology as knowledge (the know-how of technological innovation) and technology as hardware (equipment, machines, tools and all other instruments that humans use in productive activities). Other definitions conceive technology as a process that begins with a need and ends with a solution. That is, technology can be seen as "embodiments of human desires and ambitions, as solutions to complex problems, and as interacting networks and systems".

Discussion Activity

Present a philosophy of technology. You may explore the following link for help.

Uidlcphi304_phil-of-tech.blogspot (page 49 of original script)

Post your findings on Study Session Three forum page on course website.

Study Session Summary

Summary

In this Study Session, You learnt thatclarity in defining technology is very essential in the attempt to understand science and technology. We noted that technology learns from nature in some cases, and brings to finish the work of nature in some other cases and that Technology has always been in existence as long as humans have existed.

Assessment

Assessment

SAQ 4.1 (tests Learning Outcome 4.1)
Give a holistic definition of technology.

SAQ 4.2 (tests learning outcome 4.1 and 4.2)
Discuss at conceptual issues in the definition of technology.

Study Session 5

The Relationship between Science and Technology

Introduction

Inthis Study Session, we will discuss how philosophy interrogates both science and technology.

Learning Outcomes

Outcomes

When you have studied this session, you should be able to:

5.1 *outline* the points of convergence between science and technology.

5.2 *discuss* the points of divergence between science and technology.

5.1Points of Convergence between Science and Technology

How related or different is science to technology? The relation and difference of science and technology has been the subject of debate among scholars, especially philosophers of science and technology. Some scholars argued that technology is different from science in that while science concerns itself with what is, technology is concerned with what is to be.Others have emphasized that while the scientist is preoccupied with how things are in nature the engineer is preoccupied with how things ought to be.

In what seems like a contrary opinion, other philosophers of technology have argued that technology is applied science. This preserves the differences between science and technology. It is believed that technology is about activity or practice but this activity or practice is underpinned by theory. This levels technology with science and differentiates it from crafts and arts. Two sets of technological theories can be identified. The first sets are substantive theories, and they provide knowledge regarding the object of action. That is, they are largely applications of scientific theories. The second sets are operative theories, and they are primarily concerned with activities or practice. Even though operative theories are not like substantive theories which depend on scientific theories, they share a relation with science in the employment of scientific method such as the use of theoretical concepts and abstractions, modification of theories, prediction, etc. Thus, “substantive technological theories are always preceded by scientific theories, whereas operative theories are born in applied research and may have little if anything to do with substantivetheories this being why mathematicians and logicians with no previous scientific training can make important contributions to them".

Tip

The relationship between science and technology is mutual or reciprocal. The scientific knowledge world would not have been possible without the precise instruments of observation, manipulation and calculation that a refined modern technology provides. Thus it is the case that modern technology is very necessary to modern forms of science as science is also very necessary for modern forms of technology.

5.2 Difference between Philosophy of Science and Philosophy of Technology

What is clear from the previous section is the fact that science and technology are related in some sense and different in others. This can be buttressed with the fact that scientists and engineers initially receive the same training at the start of their education, which only gradually diverges into pure science or engineering curriculum as the training advances.

This relative relation and difference also holds between philosophy of science and philosophy of technology. Philosophy of science is basically concerned with investigating the methods of generating scientific knowledge, the grounds for accepting certain scientific theories as true and others as false. Thus the questions asked by philosophers of science usually concerned the entire community of scientists, their aims, arguments, choices, etc. Philosophy of technology does not concern itself with or asks questions that borders on the community (paradigm) of engineers, rather it is concerned with the place and meaning of technology in human society, culture and existence.

It is claimed that "both philosophy of science and philosophy of technology are twentieth century inventions, but each has followed a somewhat different set of philosophical traditions ad pursued sometimes divergent questions".However philosophy of science leads that of technology by a few decades.

Philosophy of science is an analytic transformation of epistemology in the light of the success and clarity of science. Unlike the philosophy of science, "philosophy of technology has primarily drawn its philosophers from the praxis traditions, in North America from pragmatism, phenomenology, and the neo-Marxian critical theorists, with analytic strands in a minority role".

Philosophy of technology as a self-conscious activity emerged about 100 years ago among engineers trying to give meaning to their work through reflection. This reflection paid off in two ways. First, these engineer-philosophers were able to get engineers to see technology as something different from science, and deserving of its own epistemological, metaphysical, ethical and political analysis. Second, these thinkers were able to counter the criticisms levelled against technology by philosophers such as Lewis-Munford, Martin Heidegger, or Jacques Ellul in a manner that has resulted in the criticisms of applied ethics.

Philosophy of technology is an emerging sub-discipline in philosophy which has not yet fully arrived. The flood of literature on philosophy of technology seems to suggest some form of a sub-disciplinary arrival, but the philosophy of technology has not fully arrived for two reasons. The first reason is that philosophy of technology has not generated recognizable and sustained internal arguments from the perspective of Kuhnian normal science in which a recognizable set of problems are resolved within a paradigm, It has been argued that "philosophy of technology remains more pre-paradigmatic than its family cousins, either the earlier arrived philosophy of science or its chronological peer, science studies".That is to say, while paradigmatic debates have been developed in philosophy of science and in the sociology of science, which is of the same age as philosophy of technology. The same cannot be said of the philosophy of technology.

It has also been claimed that philosophy of technology has not yet arrived because it has not been able to defend its disciplinary boundaries like philosophy of science and science studies. It has also been claimed as well that "philosophy of science takes its place among a somewhat more diverse set of disciplines which now include history, but also sociology, anthropology, political theory, etc within science studies programs and science, technology and society programs, again both in North America and the UK. In both cases, the participant disciplines have identities and patterns of recognition which the other participants recognize".

Since philosophy of technology has not been able to establish its own recognized identity amongst other disciplines, it cannot be said to have fully arrived even though there are recognizable philosophers of technology.

Note

The Relationship between Science and Technology

1) Science and technology interconnects, however, they also disconnect.
2) While science investigates nature, technology concerns itself with creating entities out of nature.
3) Science is theoretical whereas technology is applied science and more practical.
4) Philosophy of science and of technology is both twentieth century inventions, but whereas the former is an analytic transformation of epistemology, the latter draws more from the praxis traditions.
5) While philosophy of science has in-built recognizable and sustained arguments, philosophy of technology is yet to evolve defendable disciplinary boundaries.

Study Session Summary

Summary

In this Study Session,weobserved the points of convergence as against the points of divergence between science and technology, and between philosophy of science and philosophy of technology. We also speculate that philosophy of technology is still in the state of becoming due to indistinctiveness which implies lack of jurisdictional boundaries.

Assessment

Assessment

SAQ 5.1 (tests learning outcome 5.1)

Give an illustration of how science and technology interconnect.

SAQ 5.2 (tests learning outcome 5.2)

Contrast the natures of philosophy of science and philosophy of technology.

Study Session 6

Technology and Branches of Philosophy

Introduction

In this Study Session,we will learn about methodology as it bothers on technology. We will also explain the methodological problems that evolve in technology.

Learning Outcomes

Outcomes

When you have studied this session, you should be able to:

6.1*discuss* the interrelationship between technology and the following branches of philosophy:

- epistemology
- axiology
- metaphysics

6.2 *explain* the methodological problems that evolve in technology.

6.1 Technology and Epistemology

Epistemology The branch of philosophy that studies the scope, structure, conditions and validity of human knowledge

Technology has epistemological dimension. **Epistemology** is that branch of philosophy that studies the scope, structure, conditions and validity of human knowledge. Technological activities of a society reveal what some members of that society know how to do. There is a link between scientific knowledge and technological knowledge because the some of the question of modern technology associated with philosophy of technology are also found in theoretical knowledge which arises from the sciences. Hence all the problems or questions that are asked in the philosophy of science are also found in the philosophy of technology.

Epistemological question arises in the regard that scientific knowledge is an artifact of our technology tool and technique? If science is considered as a theoretical discipline, in what sense, if any,is theoretical reason and practical reason related and what is their relation to technology? In what way does thought relate to act? Between science and technology which one is primary epistemologically? There is a mutual relationship between science and technology. Epistemologically both are at par.

6.2Technology and Axiology

Axiology The branch of philosophy which deals with issues of value and aesthetics.

Technology throws up questions about **axiology** because vital issues of values are involved in it. Axiology is that branch of philosophy which deals with issues of value and aesthetics. Technology of any society reveals the technological preference of the members of that society and the ends and means they consider as legitimate in achieving this preference. Value is a necessary component of technology because without it there can be no proper technology. This is to say that knowledge has to bond with value in order to have a proper technology.

Technology raises some important traditional questions of aesthetics and ethics such as beauty and ugliness, ends and means, good and evil, right and wrong.Modern technology has thrown up many new ethical questions because it now affects every facet of human life. Not only this, it is of major concern in terms of the environmental impact it has wrought. Furthermore technology has enormously possibilities to open up new range of human power for good or evil, it is imperative that ethical questions have to be put on the agenda of philosophy of science and technology.

6.3Technology and Metaphysics

Metaphysics The branch of philosophy that deals with reality

Metaphysics as a branch of philosophy deals with reality. In a sense, therefore, technological innovations have implications for metaphysics. Since human thought and decision are the underlying factors of technological knowledge, it may be proper to say one's theory of reality determines one's perspective of technology. In this regard, is reality not just a product of human thought and decision? or is the other side of the coin that human ends and activities are the manipulation of technology? In this regard also some questions are thrown up. What is human nature? Are we significantly different from machines? Can certain developments in technology reveal certain facts about certain traditional problems in philosophy such as questions bothering on the mind/body dichotomy, personal identity etc.

If technology can give us a new form of reality, what are the best ways of representing reality? Can technology provide a better way of representing reality? Or can it provide a new form of understanding the nature of things in totality. What is the status nano-technology? Can we say that we are now in a post-mechanistic metaphysics which has implications for newer technologies?

In what sense can we say that the newer technologies will influence the way we view reality and what implications will these have on how we relate to other people and the world? Posing these questions is simply a way to bring out the fact that metaphysical theories may not only describe or represent the world but would also play a vital role in making us to look at it differently in terms of changing it.

○ ITQ There is a relationship between metaphysics and technology. (True / False)

● ITA True. Metaphysics deals with reality; while technology, through its activities, has implications for reality.

6.4Technology and Methodology

Technology is regarded by some thinkers as a technique or **methodology**.(See Study Session 2, 2.1.1 for information on methodology.) This characterization might have over blown the similarity between technology and methodology but there is no doubt that the rational organization of procedure technique is the hallmark of modern technology. Questions of method in general are of vital importance in philosophy of technology. The critical way of thinking involves avoidance of contradictions and confusions. Furthermore; it involves constancy, coherence and adequacy. This involves that any theory or concept to be employed in philosophy of that is developed. At the moment philosophy of technology is unfortunately not well developed and as such no consensus on certain basic terms, even the concept of technology is still mired in controversy. It is therefore necessary that the methodology of technology has to be developed.

Note

Technology and some core branches of philosophy interconnect in the sense that:

1) Epistemology provides epistemic/conceptual cum explanatory devices, inter-theoretic reduction, models, and theories which guide technological innovations.

2) Axiology guides the invention and usage of technological innovations with regards to values, mores, norms and traditions of human societies.

3) Metaphysics and technology bother on reality. While metaphysics inquires deeply into the nature of reality, technology works on nature to reflect hidden possibilities within reality.

4) Methodology, and the right operational methodology, remains a problem to the flourishing of philosophy of technology.

Study Session Summary

Summary

In this Study Session, you learnt that there are someinterconnectivity between technology and core branches of philosophy. Epistemology provides epistemic/conceptual cum explanatory devices, inter-theoretic reduction, models, and theories which guide technological innovations.Axiology guides the invention and usage of technological innovations with regards to values, mores, norms and traditions of human societies.Metaphysics and technology bother on reality. While metaphysics inquires deeply into the nature of reality, technology works on nature to reflect hidden possibilities within reality.

Assessment

Assessment

SAQ 6.1 (tests Learning Outcome 6.1)

What is the relationship between technology and the following braches of philosophy?

i. epistemology
ii. axiology
iii. metaphysics

SAQ 6.2 (tests Learning Outcome 6.2)

Highlight the problem of methodology in philosophy of technology.

Study Session 7

Karl Marx and Martin Heidegger on Technology

Introduction

In this Study Session, we will look at Marx's view on technology. We will also explore Heidegger's concept of technology.

Learning Outcomes

Outcomes

When you have studied this session, you should be able to:
7.1 *discuss* Marx's view on technology.
7.2 *discuss* Heidegger's view of technology.

7.1 Marx's View of Technology

Marx has an ambiguous view of technology. He had both negative and positive views. His view at one point was positive while later it changed and became negative. This is because the first sentence of Marx's paper "the machine versus the worker" expresses Marx's negative disposition towards technology: "The instrument (technology) of labour strikes down the labourer". In fact, Marx branded technology as an antagonist and unfavourable competitor by asserting that:

> *This direct antagonism between the two (technology and workers) comes out most strongly, whenever newly introduced machinery competes with handicrafts or manufactures, hand down former times… But machinery not only acts as a competitor who gets the better of the workman, and is constantly on the point of making him superfluous. It is also a power inimical to him, and as such, capital proclaims it from the roof tops and as such makes use of it.*

Marx was writing from the background of a German ideology where machines, like money, are seen as destructive forces of the mode of production. In fact, Marx presents only the negative aspects of machine labour in the communist manifesto, and did not recognize how machine production of material wealth could also be a positive good in a different mode of production.

The basic thrust of Marx's writings is the alienation of humanity from its essence. The concept of alienation has featured in the works of great thinkers as Hegel, Rousseau, Locke, Smith and Feuerbach. Marx adopts this concept and transformed it to the point that it became “a ringing indictment not only of the forms of life produced by the capitalist world, but also of the forms of thought characteristic of the alienated worlds of both nascent and developed capitalism”. In Marx’s view, work ought to be a medium through which man attains self-actualization. But this, given the mode of production in capitalism, is not realizable. In capitalism work is alienated, activity stunted and humanity in this sense is eliminated.

In his earliest writings, Marx takes objectification as the most basic feature of all human activity. Objectification means the mixing of human force with passive matter of nature. Marx believes that any individual who works on nature in this manner objectifies his or her essence, leaves his or her mark on nature. However, man can produce in this way only when he is free from physical need; in fact, he truly produces only in freedom from such need. This way, nature appears as his work and reality, and he can therefore contemplate himself in a world he has himself created. Individual objectification alone cannot transform the world this manner, rather it is collective objectification s brought about by progressive humanization and spiritualization of the natural world. That is to say, I only know and understand myself as a human being insofar as I am integrated into a social world of human objectification.

According to Marx, this objectification becomes alienated in capitalism given its attendant unjust distribution of the fruits and tools of production. Producers no longer get to enjoy the products of their hands Marx succinctly makes this point in his *Economic and Philosophical Manuscripts* (1844):

> *The object that labour produces, its products, stands opposed to it as something alien, as a power independent of the producer. The product of labour is labour embodied and made material in an object, it is the objectification of labour…In the sphere of political economy, this realization of labour appears as a loss of reality.For the worker, objectification as loss of and bondage to the object, and appropriation as estrangement, as alienation.*

Interpreting this passage, Marx claims that in order to survive, in a political economy, people must work or appropriate the necessities of physical life by selling their labour. But instead of getting their produce in exchange for their labour, they get money which they exchange for other things. This way, the worker becomes alienated from his objectifying activity. Not only that the worker is not given a just equivalent for his or her objectifying labour, his or her activity is not undertaken in freedom from physical need, and as such the activity is not one of self-actualization. Thus, the worker is alienated from three things:

(i) from the objects produced;
(ii) from the means of production (i.e. the tools and instruments through which production is carried out); and
(iii) from the process of objectification itself, because he or she finds that his or her practical life activity stunts, abuses and undermines itself.

Marx's account of alienation comprises five kinds of (overlapping) alienations: theological, political, psychological, economic and technological. Each of these has a corresponding metaphysical object into which the human essence is alienated. For Marx, even though these objects are the creation of humans, they turn out to exert dominance on human beings as alien powers over which they (humans) have no control. These objects include God or gods (theological), the state (political), the ruling class ideology (psychological), commodity (economic) and the industrial machine (technological). Combined, these structures alienate human beings from their essence, from their fellow human beings.

Marx's idea of technological alienation is captured in his "Machine Fetishism". This is a situation where the practical activities of human beings are undertaken as labour by machines that they neither own nor understand. "Such labour is characterized by the reduction of the worker to an extremely partial use of his or her faculties. In addition, it is characterized by the repetition of a single function for long periods". Beyond this, Marx sees technology as the most powerful weapon for repressing strikes and revolts of the working-class against the autocracy of capital. Marx argues that:

> *The steam-engine was from the very first an antagonist of human power, an antagonist that enabled the capitalist to tread underfoot the growing claims of the workmen, who threatened the newly born factory system with a crisis.*

The foregoing suggests that since only fewer workers would be required to operate given machines in a factory, mass revolts of workers would be meaningless, if not nonexistent. Marx again writes:

> *The characteristic feature of our modern mechanical improvements is the introduction of the self-acting tool machinery. What every mechanical workman has now to do, and what everybody can do, is not to work himself but to superintend the beautiful labour of the machine that depend exclusively on their skills, is now done away with. Formerly, I employed four boys to every mechanic. Thanks to these new mechanical combinations, I have reduced the number of grown-up men from 1,500 to 750. The result was a considerable increase in my profits.*

Thus, alienation becomes the widespread effect of the introduction of machines as replacement for human labour. The increased introduction of machines to all aspects of production expands the scope of technological alienation. In other words, and as Marx claimed, alienation is made worse by the introduction of machines into production. Since machines can automatically perform all the interesting aspects of production, they render the workman's activity dull and monotonous. According to Wending, "Marx also shows how workers perceive steam technology as a dangerous competitor. Workers then revolt against technology –that is, against the means of production –and smash machines".

Since Marx was against alienation in general, it follows that his perception of technology, especially in production, is negative given the alienating power it exerts on human beings. Thus, the machine is the final "metaphysical object" of Marxian theory of alienation it occupies the same structural position as God, the state, ruling class ideology and commodity in theological, political, psychological and economic forms of alienations respectively.

Marx's latter writings on science and technology are underscored by his understanding of alienation and objectification and his analysis of the fact that even though machines were introduced and played a role in alienated production, they could play some positive role in objectification. This led Marx, to emphasize different things in his analysis of machines in terms of either alienation or objectification. "In the latter context, Marx becomes increasingly sympathetic to the socialist utopian scenario in which machines perform arduous labour instead of human beings".Therefore, we can say that Marx's disposition towards technology (machine fetishism) in terms of alienation is negative, while it is positive in terms of objectification, precisely in the areas of functions which humans cannot do or which is very difficult for them to do.

Tip

Marx's ambiguous perspective on technology is as a result of technology's alienation of man from the process of work and production by displaying dominance on man just as an alien power over which man as no control.

7.2Martin Heidegger on Technology

Our society today is technology driven. Humanity is in danger of this trend because the world today only wants to hear of science and technology. Heidegger decries this trend and argues for a return to the original conception of 'techne', which safeguards humanity and arts. According to him:

> *Everywhere we remain unfree and chained to technology, whether we passionately affirm or deny it. But we are delivered over to it in the worst possible way when we regard it as something neutral; for this conception of it, to which today we particularly like to do homage, makes us utterly blind to the essence of technology.*

Heidegger argues that the essence of technology is by no means anything technological, and until we understand them separately we cannot adequately fathom the danger posed by technology. Heidegger essentially conceives technology as a human activity, a means to an end or an instrument of conquering nature. Even though this conception is correct to a large extent, Heidegger asserts that it does not and cannot show us the essence of technology. Etymologically, Heidegger understand 'techne' as 'bringing-forth' or a 'revealing'. That is, it is the name not only for the activities and skills of the craftsmen, but also for the arts of the mind and the fine arts. Techne belongs to bringing-forth. Thus techne as technology means to unravel the concealed, to reveal something originally covered or hidden. In Heidegger's words, "technology is a mode of revealing. Technology comes to presence (West) in the realm where revealing and unconcealment take place, where aletheira, truth, happens”. Heidegger notes that what is troubling in this definition is that, while it conveniently applies to the Greek’s conception of the technique of the handicraftsman, it does not fit modern machine-powered technology; this is what informs his questioning of technology.

In Heidegger’s opinion, modern technology is also a mode of revealing, but its revealing is one of “challenging” (Herausfordern). By this challenge, modern technology unreasonably demand nature to supply energy that can be extracted, stored, and put to use at any time needed. For instance, when a portion of land is channelled into putting out coal, the earth reveals itself as a coal mining district, the soil as a mineral deposit. In the same way, nature can be challenged for air or to yield nitrogen, the earth to yield ore, ore to yield uranium, uranium to yield atomic energy, which can be released peacefully or destructively. Thus, modern technology is characterized by a challenging forth, a challenge which unlocks the energy concealed in nature. “What is unlocked is transformed, what is transformed is stored up, what is stored up is, in turn, distributed, and what is distributed is switched about ever anew. Unlocking, transforming, storing, distributing, and switching about are ways of revealing”. Heidegger calls this calling-forth, in order to gather, assembly and order at will, “Ge-Siell” or Enframing. According to him, modern physics is the herald of enframing because it has unconcealed what were originally concealed in nature. The essence of modern technology lies in enframing. In the midst of all this, man is endangered, and even God could lose all that is exalted, holy, and the mysteriousness of his distance.

Heidegger’s argument is that because modern technology “enframes” the universe and everything in it we become cut off from nature. The craftsman’s art techne is a bringing forth, that works in partnership or cooperation with the nature of materials used in constructing artifact, such as a chair or a house. But modern technology is a challenging-forth, which does not cooperate with nature but attempts to change it, to make it flexible, and longer and lasting. For example, cloning or genetic engineering “challenges” the natural bounds of the body creating an entirely new artifact with different characteristics. As Heidegger sees it, earlier inventions of man did not permanently impose a new form onto nature. A carpenter only temporarily impose the form of a chair onto wood because once the chair is spoilt, that wood still maintains its natural characteristics to not and decompose in the same manner as a fallen tree in the forest. In contrast, modern technologies do not cooperate with nature in this manner. For instance, a nuclear engineer can manipulate the structure of nature’s elements and come up with artificial elements such as plutonium is designed never to cooperate with nature by returning to the uranium from which it was made. Also, the genetically modified human is designed never to return to the natural characteristics of the material from which it was made (e.g. a sick or weak body). Above all, modern technologies of this sort do not reveal nature, and since our society is filled with so much artificial and unrevealing artifacts, Heidegger argues that we are cut off from, become unaware of, or forget the essence of nature.As he puts it, “Enframing blocks the shinning-forth and holding sway of truth.

There is no doubt that Heidegger has a strong case. But can we return to the pre-technological age in order to recapture our essence and that of nature? Some scholars believe that we cannot return to pre-technological age anymore. With technology we have been able to surmount certain human sufferings brought about by nature. Hence technology is a necessary evil which we have to accommodate in human's life.

Note

Karl Marx had a dualistic conceptualization of technology, as objectifying human essence and at the same time alienating humanity, Heidegger warns against the dangerous trend of technology and contends for a return to the understanding of technology as a techne.

Discussion Activity

In what way is Heidegger's view different from that of Marx?

Post your response on Study Session Seven forum page on course website.

Study Session Summary

Summary

In this Study Session, we discussed about both Marx's and Heidegger's views of technology. We speculated that Marx had a dual conceptualization of technology. He conceives it from both positive and negative dimensions. For Heidegger, however, it was basically from a negative dimension as it sees it as a necessary evil we have to put up with.

Assessment

Assessment

SAQ 7.1 (tests Learning Outcome 7.1)
What are the views of Marx on technology?

SAQ 7.2 (tests learning outcome 7.2)
Discuss Heidegger's views on technology.

Study Session 8

Technology and Its Impact on the Environment

Introduction

In this Study Session, we will discuss the impact of technology on the environment. We will also draw attention to the positive and negative aspect of technology.

Learning Outcomes

Outcomes

When you have studied this session, you should be able to:

8.1 *discuss* air pollution as an impact of technology on the environment.

8.2*explain* the impact of emission of carbon dioxide as an impact of technology on the environment.

8.3 *discuss* the effects of global warming on the environment.

8.4*highlight* the positive and negative aspects of technology.

8.1Air Pollution as an Impact of Technology on the Environment

The impacts of technologies on our environment are obvious and witnessed by everyone. In fact, environmental issues are the biggest challenge facing our planet earth today: depleting ozone layer, global warming, reduction of vegetation, extinction of animals, climate change, etc. These problems are largely associated with technological advancements in industries and establishments of power plants. Let us take examples from coal combustion and conversion technology to illustrate this point.

Coal is an energy source whose preparation goes through several gaseous industrial processes. It is formed by the decomposition of the remains of plants in swamps or river deltas and consists of two stages of formation: Biochemical and Geochemical. Coal contains elements such as carbon, hydrogen, oxygen, nitrogen, and sulphur. Experts have predicted that the large-reserves of coal world-wide ensures that coal will remain crucially important energy source in the forthcoming era of energy shortage (e.g. crude oil and natural gas, the energy sources upon which the present economic growth of the industrial world depends).

The preparation of coal involves the removal of its elements. In the process, these elements results in pollutants (particulate malter, sulphur, nitrogen oxides, carbon dioxide, etc) which affect human health, ecology, global climate, and leads to haze and smog, among others. For example, Merrick states that the gases produced as a result of coal combustion contain particulate material, some of which is carried into the atmosphere with the flue gases. This particulate emission results in respiratory diseases urban smog that increases mortality. The London smog of 1952, for example, has been estimated to have caused 4000 additional deaths.

8.2 Emission of Carbon Dioxide and Global Warming

Another very important element in coal technology is carbon dioxide, the fifth most abundant gas in the atmosphere (after nitrogen, oxygen, water vapour and argon), and which plays important roles in life processes. Usually, carbon dioxide is not regarded as a pollutant, but its increased concentration in the atmosphere is reputed as the cause of climate change and global warming. According to Merrick, reliable measurements show that carbon dioxide concentration in the atmosphere was 315ppm (by volume) in 1958, 338ppm in 1980 (an average increase of 0.3 percent, or 1ppm, per annum). "For comparison, it has been estimated that the carbon dioxide concentration at the beginning of the industrial revolution was 290ppm".How does carbon dioxide cause global warming?

Global warming can be easily understood (given our discourse from the foregoing paragraph) as an increase in the average temperature of the earth as a result of natural calamities (such as volcanic eruptions, movement in the technonic plates, exploding of sunspots, etc) and man-made activities (such as deforestation, power plant installations, burning of fossil fuels, generation of poisonous gases, etc). Global warming is not an emerging environmental issue associated with technology; its consequences are already being felt: the melting of glaciers, rising of the sea levels, disintegration of wild-life, drying up of forests, increasing rain fall, etc. RajibSingha properly highlights these effects in his assertion that global warming…

a) Is causing changes in the climate which are too rapid for some living things to adapt to

b) Is causing earth's ice sheets to melt thus, increasing the sea level

c) Is causing weather to become extreme; characterized by the development of major storms, longer spells of drought, more rain than required, and alterations in the life-supporting ranges for the survival of plants and animals

d) It may, or is causing heavy precipitation even in places which stopped receiving heavy rainfall

e) Also, causes water bodies to absorb heat more than usual. This is because, with the glaciers melting down, heat is reflected in low amounts and absorbed in high amounts by sea and oceans thus, further increasing the temperature.

The constant day-to-day variations in climate and its consequent effects raise fear as to what become of our world a couple of decades from now, and what would be the fate of future generations.

In order to properly understand how carbon dioxide causes global warming, scientists came up with the 'greenhouse effect' theory. A greenhouse is a building where plants are grown under a controlled environment. Control in the sense that the building is rooted with different but transparent materials like plastic or glass. With this, the building allows solar radiation to be absorbed by the plants by letting it in, but it disallows the heat generated from getting out or escaping. Water vapour, methane, nitrous oxide, ozone and carbon dioxide are the main greenhouse gases in the earth's atmosphere. "What these gases do is, they form a kind of wall over the atmosphere, which although lets the solar radiation to enter, but keeps some of the heat that is radiated back from escaping into the space; similar to what is done by a greenhouse".Thus, these greenhouse gases are seen as the immediate causes of global warming since, by their activities, the heat that is to be radiated back is trapped and results in the increase of atmospheric temperature.

However, carbon dioxide is considered the worst culprit because its emission and concentration rates in the atmosphere are higher than those of other gases. These higher emission rates result from combustion of coal and fossil fuels in factories, vehicles, homes, and in electricity generation, the burning of bush and forests, etc. Therefore, the trapped heat that results from the other gases is relatively small compared to carbon dioxide given its increase number of emitting sources in the world.

As we have seen, the impact of technology on nature is troubling and its effects cannot be overemphasized. In fact, some scientists have predicted that some cities of the world would be submerged by water 100 years from now as a result of global warming (Lagos inclusive). This problem generates issues of ethical reflections both in the ethics of technology and in environmental ethics in particular relation with responsibility. Governments and people of the world must take responsibility) or their actions and in actions) and stop paying lip-science to efforts of combating global warming, especially in the area of reduction of carbon dioxide emission into the atmosphere.

8.3Effects of Global Warming on the Environment

1) Rapid changes in the climate which is detriment to the existence of some living things.
2) Melting of earth's ice sheets, thereby leading to rise in sea level.
3) Extremely harsh weather condition characterized by the development of major storms, longer spells of drought, excessive rainfall, and alterations in the life-supporting ranges for the survival of plants and animals.
4) Heavy precipitation even in places which stopped receiving heavy rainfall.
5) Water bodies' absorption of heat beyond the normal due to the melting of the glaciers. Heat is thus reflected in low amounts and absorbed in high amounts by sea and oceans thus, further increasing the temperature.

8.4 The Positive and Negative Aspects of Technology

We must bear in mind that even though technology has emancipated itself into semi-independent cognitive discipline, it still has many links with science. That is to say, science and technology are intimately related to the extent that you can hardly talk of the one without the other. This idea has led to a blending or hybridization of science and technology into what is now known as techno science. That said, it is irrational to hold that al technology is evil or neutral. Some technologies are inherently good and, perhaps, neutral; while others are inherently evil and non-neutral. How do we maintain a balance between this inherent goodness and evilness? Since technology, according to Heidegger, enframes us and deprives us and nature of essence, some scholars have interpreted Heidegger as suggesting a retreat to a non- technological past. Is this possible?

There is no gainsaying that modern society is constituted or shaped in various ways through technological systems and networks. For instance, human experiences such as birthing babies, education, exercising citizenship, combating sickness and diseases, going to work, etc, are all mediated by technology. Given this inevitable tangle of technology with society, Thomas Misa has argued that there is no way of retreating or responsibly escaping this condition of modernity.

Despite these positives, technology cuts deeply with its other edge and endangers humanity, the environment, and all of nature. Our inescapability forms the enframement and, according to Marx, alienation of technology suggests that we must seek ways of confronting it (technology) constructively. We need not rebel against all technology because as humans we have wisdom and free will to choose between which technology to use and which to rebel against. This calls for a more responsible use of technology by consumers and, most importantly, a more responsible creation of technologies by engineers and managers who cannot run away from the fact that they are morally responsible to humanity. This and many other related issues should not escape the critical gaze of the philosopher of technology.

Discussion Activity

Is technology more helpful than harmful?

Post your submission on Study Session Eight forum page on course website.

Study Session Summary

Summary

In this Study Session, you learnt the impacts of technology on the environment. In spite of the many positive implications of technology on the society, it has also brought some adverse effects such as air pollution and global warming. We finally discussed that technology has come to stay, and that its emergence issues necessitate responsibility for sustainable development.

Assessment

Assessment

SAQ 8.1 (tests Learning Outcome 8.1, 8.2, 8.3 and 8.4)

What is the impact of technology on the environment?

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Karl Marx and Martin Heidegger of Technology

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Notes on Self-Assessment Questions

Study Session 1

SAQ 1.1

We don’t know what you have considered, but your answers may include the following:

rationality, hypothesis, testing or experimenting and theory modification, theoretical progression and empirical verification and inductivism.

SAQ 1.2

The substance of science is distinct from pseudo-science because of the following:

- process of observation, that is observation in science is meticulous,
- experimentation, a hypothesis is scientifically genuine if it is testable, clear in predictions and avoid ad hoc exceptions.
- recourse to prior theory and reflective imagination.

Study Session 2

SAQ 2.1

Five steps are collectively known as the principles of inductivism. They are

(i) Observation

(ii) Hypothesis

(iii) Experiment

(iv) Law, and

(v) Theory.

SAQ 2.2

- The practical problem concerns the number of observations which must be made before we can generalize, whether we can ever make sufficient number of observations before making generalizations.
- The theoretical problem lies in the fact that science is construed as an empirical discipline in that it claims nothing beyond what has been observed, thereby making observation the core distinguishing factor between science and pseudo-science.

Study Session 3

SAQ 3.1

Normal science is a period when scientists are basically preoccupied with solving a problem within a paradigm without questioning the paradigm.

SAQ 3.2

In normal science, a great deal of research effort is aimed at extending a theory confirmed for a broad domain to new kinds of problems and improving its accuracy. However, since theories always have limited domains of validity, this ultimately leads to the falsification of the theory, the result of which is a scientific revolution searching for a new theory embodying a new point of view whose domain of validity includes that of the old theory plus a wider range of phenomena.

SAQ 3.3

During periods of scientific crisis, Kuhn's position is that the scientists' choice of paradigm is not purely rational, but is at times influenced by unscientific elements as personal ambitions and social pressure.

Study Session 4

SAQ 4.1

Technology can be defined as the innovative application of scientific knowledge in such a way as to develop a machinery or instrument for practical purposes.

SAQ 4.2

Major conceptual issues revolve around "techne".

- As 'techne', technology which translates into 'craft' or 'art', can however also be seen as a practice that is grounded in theoretical knowledge or 'an account', thus linking it closely to notions of expertise or know-how.
- Some other interpreters have argued that there are fundamental differences between techne and technology. They argue that while techne is limited in function, technology is characterized by its complete lack of limitation. Technology is offensive.

Study Session 5

SAQ 5.1

Although we do not know your exact example, but here are two ways by which science and technology connects

i. Technology is about activity or practice but this activity or practice is underpinned by theory. This levels technology with science and differentiates it from crafts and arts.

ii. The relationship between science and technology is mutual or reciprocal. The scientific knowledge world would not have been possible without the precise instruments of observation, manipulation and calculation that a refined modern technology provides. Thus it is the case that modern technology is very necessary to modern forms of science as science is also very necessary for modern forms of technology.

SAQ 5.2

While, philosophy of science is an analytic transformation of epistemology in the light of the success and clarity of science; philosophy of technology as a self-conscious activity emerged about 100 years ago among engineers trying to give meaning to their work through reflection and has primarily drawn its philosophers from the praxis tradition.

Study Session 6

SAQ 6.1

i. Both epistemology and technology deals with knowledge. While epistemology studies the scope, structure, conditions and validity of human knowledge, technology reveals what some members of that society know how to do.
ii. Axiology and technology both deals with value issues. While axiology studies issues that bother on value and aesthetics, technology the value or aesthetical preference of the members of that society and the ends and means they consider as legitimate in achieving this preference. Value thus, though an axiological subject matter, is a necessary component of technology because without it there can be no proper technology.
iii. Metaphysics deals with reality while technology, through its activities, has implications for reality.

SAQ 6.2

Philosophy of technology is unfortunately not well methodologically developed and as such is devoid of consensus on certain basic terms.

Study Session 7

SAQ 7.1

We do not know what considered as the views of Marx, but he had a dual conception of technology. Marx's initial position was positive as he held that technological innovation would support the more blissful stages of socialism and communism of the future. In the latter context, however, Marx becomes increasingly sympathetic to the socialist utopian scenario in which machines perform arduous labour instead of human beings. This trend, according to Marx, extends to a situation whereby the practical (economic) activities of human beings are undertaken as labour by machines that they neither own nor understand. Such labour underscores the reduction and gradual alienation of the worker to an extremely partial use of his or her faculties. In addition, it is characterized by the repetition and attendant redundancy of a single function for long periods.

SAQ 7.2

Essentially, Heidegger sees technology as a human activity or instrument directed towards an end which is the conquering of nature. On the other hand, he decried the imposition of the materialistic aspect of technology over the techne aspect which signifies the activities and skills for the arts of the mind and the fine arts. To Heidegger, techne connotes bringing-forth. Thus technology means to unravel the concealed, to reveal something originally covered or hidden. In Heidegger's words, "technology is a mode of revealing.

Study Session 8

SAQ 8.1

Positively, technology affects the environment in the sense that technological innovations and activities such as the construction of roads, of buildings, bridges and so on add aesthetic value to the environment and make existence more comfortable for humans. However, the resultant effects of these technological activities have negative effects such as depletion of the ozone layer and the resultant global warming, environmental pollution, climate change and so on. Technology therefore bears more negative effects on the environment than otherwise