MARIANO MARCOS STATE UNIVERSITY
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History and Philosophy of Science

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The Nature of Science

The world is understandable

Objective:

- discussed the historical background of Science
- internalized the nature of Science
- applied practical teaching practices in teaching Science

Meaning of Science and Technology

- The study of how social, political and cultural values affect scientific research and technological innovation, and how these, in turn, affect society.

- The field is related to history and philosophy of science

- Broader emphasis: social aspects of science and technology

A. The scientific world view

- things and events in the universe occur in consistent patterns that are comprehensible

- through the use of the intellect, and with the aid of instruments that extend the senses, people can discover patterns in all of nature

- assumes that the universe is a vast single system in which the basic rules are everywhere the same

A. The scientific world view

- The principles of motion and gravitation that explain the motion of falling objects on the surface of the earth also explain the motion of the moon and the planets

- With some modifications over the years, the same principles of motion have applied to other forces—and to the motion of everything

Scientific ideas are subject to change

- Science is a process for producing knowledge that depends on making careful observations of phenomena
- inventing theories for making sense out of those observations.
- Change in knowledge is inevitable
- new observations may challenge prevailing theories
- another theory may fit just as well or better, or may fit a still wider range of observations

Scientific ideas are subject to change

- the testing, improving and discarding of theories, whether new or old, go on all the time.

- even if there is no way to secure complete and absolute truth, increasingly accurate approximations can be made to account for the world and how it works

Scientific knowledge is durable

- The modification of ideas, rather than their outright rejection, is the norm in science

- powerful constructs tend to survive and grow more precise and to become widely accepted

- Continuity and stability are as characteristic of science as change is, and confidence is as prevalent as tentativeness.

Science cannot provide complete answers to all questions

- There are many matters that cannot usefully be examined in a scientific way
- beliefs that cannot be proved or disproved
- a scientific approach that may be valid is likely to be rejected as irrelevant by people who hold certain beliefs

Science cannot provide complete answers to all questions

- there are no means to settle issues concerning good and evil, (they can sometimes contribute to the discussion of such issues by identifying the likely consequences of particular actions)

B. Scientific Inquiry

- the various scientific disciplines are alike in their reliance on evidence

Scientists differ greatly from one another in:

- what phenomena they investigate and in how they go about their work;
- their recourse to fundamental principles;
- the reliance they place on historical data or on experimental findings and on qualitative or quantitative methods;

B. Scientific Inquiry

- how much they draw on the findings of other sciences

- the exchange of techniques, information, and concepts goes on all the time among scientists

- there are common understandings among them about what constitutes an investigation that is scientifically valid

B. Scientific Inquiry

- there are no fixed set of steps that scientists always follow, no one path that leads them unerringly to scientific knowledge

- there are, however, certain features of science that give it a distinctive character as a mode of inquiry

Science demands evidence

- Evidence is obtained by observations and measurements taken in situations that range from natural settings to completely contrived ones

- To make their observations, scientists use their own senses, instruments that enhance those senses, and instruments that tap characteristics quite different from what humans can sense

Science demands evidence

- Scientists observe passively (earthquakes, bird migrations), make collections (rocks, shells), and actively probe the world (as by boring into the earth's crust or administering experimental medicines).
- Scientists can control conditions deliberately and precisely to obtain their evidence.
- By varying just one condition at a time, they can hope to identify its exclusive effects on what happens, uncomplicated by changes in other conditions.

Science demands evidence

- Control of conditions may be impractical or unethical or likely to distort the natural phenomena

- Observations have to be made over a sufficiently wide range of naturally occurring conditions to infer what the influence of various factors might be.
- Because of reliance on evidence, great value is placed on the development of better instruments and techniques of observation, and the findings of any one investigator or group are usually checked by others.

Science Is a Blend of Logic and Imagination

- Scientists may often disagree about the value of a particular piece of evidence, or about the appropriateness of particular assumptions that are made
- They tend to agree about the principles of logical reasoning that connect evidence and assumptions with conclusions
- The use of logic and the close examination of evidence are necessary but not usually sufficient for the advancement of science. Scientific concepts do not emerge automatically from data or from any amount of analysis alone.

Science Is a Blend of Logic and Imagination

- Sometimes discoveries in science are made unexpectedly, even by accident.
- But knowledge and creative insight are usually required to recognize the meaning of the unexpected.
- Aspects of data that have been ignored by one scientist may lead to new discoveries by another.

Science Explains and Predicts

- Scientists strive to make sense of observations of phenomena by constructing explanations for them that use, or are consistent with, currently accepted scientific principles.

- Such explanations—theories—may be either sweeping or restricted, but they must be logically sound and incorporate a significant body of scientifically valid observations.

Science Explains and Predicts

- The credibility of scientific theories often comes from their ability to show relationships among phenomena that previously seemed unrelated.

Scientists Try to Identify and Avoid Bias

- Scientific evidence can be biased in how the data are interpreted, in the recording or reporting of the data, or even in the choice of what data to consider in the first place

- Scientists' nationality, sex, ethnic origin, age, political convictions, and so on may incline them to look for or emphasize one or another kind of evidence or interpretation

Scientists Try to Identify and Avoid Bias

- Bias attributable to the investigator, the sample, the method, or the instrument may not be completely avoidable in every instance, but scientists want to know the possible sources of bias and how bias is likely to influence evidence

- One safeguard against undetected bias in an area of study is to have many different investigators or groups of investigators working in it.

Science Is Not Authoritarian

- No scientist, however famous or highly placed, is empowered to decide for other scientists what is true, for none are believed by other scientists to have special access to the truth

- There are no pre-established conclusions that scientists must reach on the basis of their investigations.

Science Is Not Authoritarian

- Challenges to new ideas are the legitimate business of science in building valid knowledge

- When someone comes up with a new or improved version that explains more phenomena or answers more important questions than the previous version, the new one eventually takes its place

C. THE SCIENTIFIC ENTERPRISE

- Science as an enterprise has individual, social, and institutional dimensions.

Science Is a Complex Social Activity

- Scientific work involves many individuals doing many different kinds of work - may focus on scientific knowledge either for its own sake or for a particular practical purpose, and they may be concerned with data gathering, theory building, instrument building, or communicating.

- Science inevitably reflects social values and viewpoints
- women and people of color were essentially excluded from most of science by restrictions on their education and employment opportunities;

Science Is a Complex Social Activity

- The remarkable few who overcame those obstacles were even then likely to have their work belittled by the science establishment.
- The direction of scientific research is affected by informal influences within the culture of science itself, such as prevailing opinion on what questions are most interesting or what methods of investigation are most likely to be fruitful.

Science Is a Complex Social Activity

- Elaborate processes involving scientists themselves have been developed to decide which research proposals receive funding, and committees of scientists regularly review progress in various disciplines to recommend general priorities for funding.

- Scientists are employed by universities, hospitals, business and industry, government, independent research organizations, and scientific associations.

Science Is Organized Into Content Disciplines and Is Conducted in Various Institutions

- Disciplines differ from one another in many ways, including history, phenomena studied, techniques and language used, and kinds of outcomes desired.

- Advantage of disciplines: they provide a conceptual structure for organizing research and research findings

Science Is Organized Into Content Disciplines and Is Conducted in Various Institutions

- Scientific disciplines do not have fixed borders - Physics shades into chemistry, astronomy, and geology, as does chemistry into biology and psychology, and so on.

- New scientific disciplines (astrophysics and sociobiology, for instance) are continually being formed at the boundaries of others

Science Is Organized Into Content Disciplines and Is Conducted in Various Institutions

- Universities, industry, and government are also part of the structure of the scientific endeavor.

- University research usually emphasizes knowledge for its own sake

- Educating successive generations of scientists, mathematicians, and engineers

Science Is Organized Into Content Disciplines and Is Conducted in Various Institutions

- Industries and businesses usually emphasize research directed to practical ends, but many also sponsor research that has no immediately obvious applications

- Funding agencies influence the direction of science by virtue of the decisions they make on which research to support

There Are Generally Accepted Ethical Principles in the Conduct of Science

- The traditions of accurate recordkeeping, openness, and replication, supported by the critical review of one's work by peers, serve to keep the vast majority of scientists well within the bounds of ethical professional behavior.

- The pressure to get credit for being the first to publish an idea or observation leads some scientists to withhold information or even to falsify their findings.

There Are Generally Accepted Ethical Principles in the Conduct of Science

- The possible harm on animal subjects that could result from scientific experiments
- the treatment of live experimental subjects.
- Modern scientific ethics require that due regard must be given to the health, comfort, and well-being of animal subjects.
- research involving human subjects may be conducted only with the informed consent of the subjects

There Are Generally Accepted Ethical Principles in the Conduct of Science

- Informed consent entails full disclosure of the risks and intended benefits of the research and the right to refuse to participate
- relates to the possible harmful effects of applying the results of research

- Whether a scientist chooses to work on research of great potential risk to humanity, such as nuclear weapons or germ warfare, is considered by many scientists to be a matter of personal ethics, not one of professional ethics

Scientists Participate in Public Affairs Both as Specialists and as Citizens

- Scientists can bring information, insights, and analytical skills to bear on matters of public concern.

- Often they can help the public to understand the likely causes of events (such as natural and technological disasters) and to estimate the possible effects of projected policies (such as ecological effects of various farming methods)

Scientists Participate in Public Affairs Both as Specialists and as Citizens

- Scientists are expected to be especially careful in trying to distinguish fact from interpretation, and research findings from speculation and opinion; that is, they are expected to make full use of the principles of scientific inquiry

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