Educational Studies

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Creative Thinking Techniques

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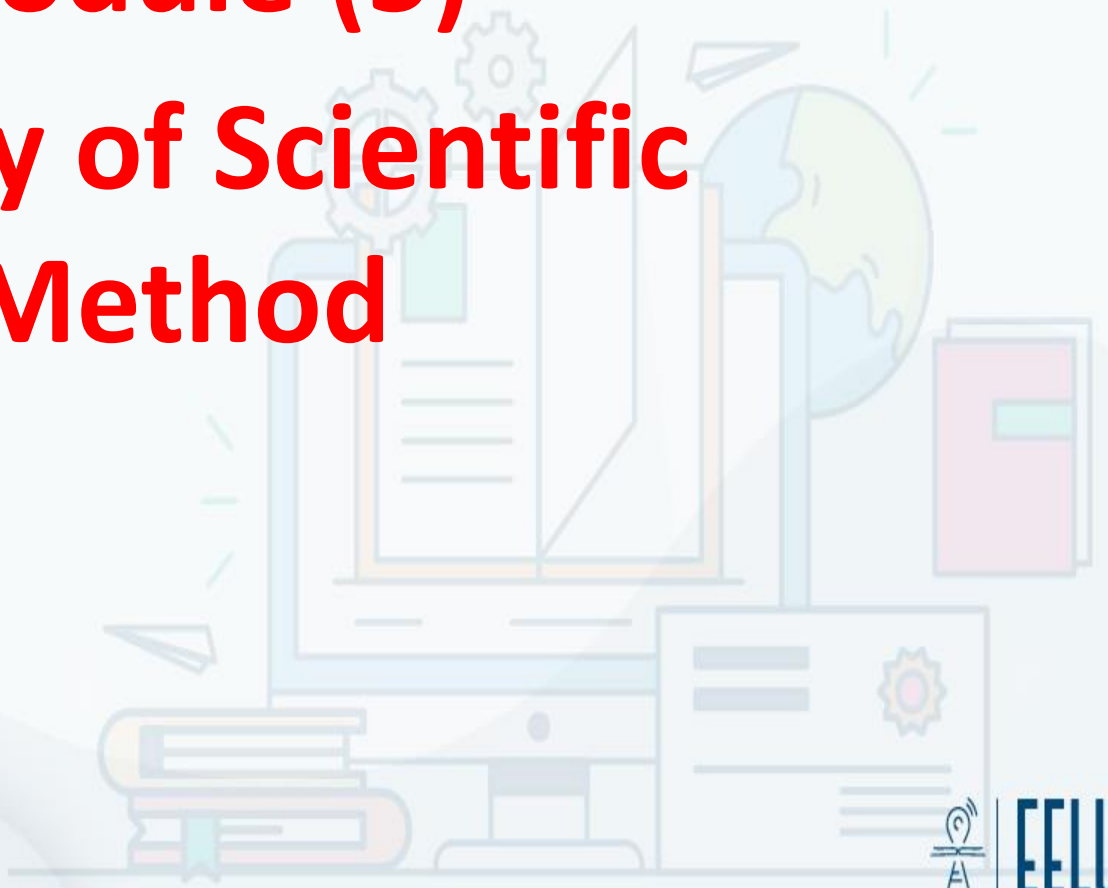
الجامعة المصرية للتعلم الإلكتروني الأهلية
THE EGYPTIAN E-LEARNING UNIVERSITY

Module (5)
History of Scientific Method



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Early forms of scientific methods

- **Lessons covered in this topic:-**
  - ✓ The Ancient Egyptian Methodology (Imhotep).
  - ✓ The Ancient Greek Methodology (Aristotle).
  - ✓ The Arabic Treatment of Methodology (Ibnal-Haytham).

The Ancient Egyptian methodology

- There are few discussions of scientific methodologies in surviving records from early cultures, especially in the descriptions of early investigations into nature.

- Some Egyptian medical textbooks apply the basic components of scientific method: examination, diagnosis, treatment and prognosis, to the treatment of disease.

The Ancient Egyptian methodology

➢ **Imhotep** (This name means “the one who comes in, with peace") one of the ancient Egyptians who used the early forms of scientific methods.

- ✓ Founder of Egyptian medicine.
- ✓ First engineer architect and physician in history.
- ✓ Author of a medical treatise remarkable for being devoid of magical thinking.

The ancient Greek methodology (Aristotle)

- **Aristotle** (384 BCE-322 BCE or BC) ancient Greek philosopher.
- Determined the orientation and the content of Western intellectual history.
- Author of a philosophical and scientific system that through the centuries became the support and vehicle for both medieval Christian and Islamic scholastic thought.
- Until the end of the 17th century, Western culture was Aristotelian.
- But he was so influential that his mistakes were never noticed.

The ancient Greek methodology (Aristotle)

- Aristotle and his contemporaries believed that all problems could be solved by thinking about them.
- For example, Aristotle thought that heavy objects would fall faster than lighter ones. Now that does seem reasonable at first. And this is how “science” was done in ancient times.
- But what did Aristotle not do? He never tested his ideas! The world would have to wait almost 2000 years for that to happen.
- Aristotle provided another form of scientific tradition: empiricism.

The ancient Greek methodology (Aristotle)

- Universal truths can be known from particular things by induction.
- To some extent then, Aristotle reconciles abstract thought with observation.
- Aristotle did not accept that knowledge acquired by induction could rightly be counted as scientific knowledge.
- Nevertheless, induction was a necessary introduction to the main business of scientific enquiry, providing the primary premises required for scientific demonstrations.
- Aristotle largely ignored inductive reasoning in his treatment of scientific enquiry.

The ancient Greek methodology (Aristotle)

- It was therefore the work of the philosopher to demonstrate universal truths and to discover their causes.
- While induction was sufficient for discovering universals by generalization, it did not succeed in identifying causes.
- The tool Aristotle chose for this was deductive reasoning in the form of syllogisms.
  - For example:
    - ✓Socrates is a man.
    - ✓All men are mortal.
    - ✓Therefore, Socrates is mortal.
    - ✓Using the syllogism, scientists could infer new universal truths from those already established.

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Deductive Reasoning

- **Deductive Reasoning** – A type of logic in which one goes from a general statement to a specific instance.
- The classic example

  All men are mortal. (major premise)

  Socrates is a man. (minor premise)

  Therefore, Socrates is mortal. (conclusion)

The above is an example of a ***syllogism***.

Deductive Reasoning

- **Syllogism**: An argument composed of two statements or premises (the major and minor premises), followed by a conclusion.
- For any given set of premises, if the conclusion is guaranteed, the arguments is said to be ***valid***.

Deductive Reasoning

- If the conclusion is not guaranteed (at least one instance in which the conclusion does not follow), the argument is said to be ***invalid***.
- ***BE CARFEUL, DO NOT CONFUSE TRUTH WITH VALIDITY!***

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Inductive Reasoning

Inductive Reasoning, involves going from a series of specific cases to a general statement. The conclusion in an inductive argument is never guaranteed.

Example: What is the next number in the sequence 6, 13, 20, 27,...

There is more than one correct answer.

Inductive Reasoning

- Here's the sequence again 6, 13, 20, 27,...
- Look at the difference of each term.
- $13 - 6 = 7$, $20 - 13 = 7$, $27 - 20 = 7$
- Thus the next term is 34, because $34 - 27 = 7$.
- However what if the sequence represents the dates. Then the next number could be 3 (31 days in a month).

Inductive Reasoning

- The next number could be 4 (30 day month)
- Or it could be 5 (29 day month – Feb. Leap year)
- Or even 6 (28 day month – Feb.)

The Arabic treatment of methodology

- During the Middle Ages (or Islamic Golden Age), early Islamic philosophy developed in scientific debates.
- Muslim scientists used experiment and quantification to distinguish between competing scientific theories.
- Several scientific methods thus emerged from the medieval Muslim world by the early 11th century.
- All of which emphasized experimentation as well as quantification to varying degrees.
- The first of these experimental scientific methods was developed by the prominent Iraqi Muslim and scientist Ibn al-Haytham (Alhazen), who used experimentation and mathematics to obtain the results in his Book of Optics(1021).

Ibn al-Haytham

- In particular, he combined observations, experiments and rational arguments to support where rays of light are emitted from objects rather than from the eyes.
- Father of optics for his influential Book of Optics. and for his experiments on: Lenses – Mirrors - The Dispersion of light into its constituent colors.
- Due to his formulation of a modern quantitative, empirical and experimental approach to physics and science, he is considered:
  - ✓The pioneer of the modern scientific method.
  - ✓The originator of experimental science and experimental physics.
  - ✓Some have described him as the "first scientist" for these reasons.

Ibn al-Haytham

- Ibn al-Haytham's scientific method was similar to the modern.
  - ✓ Explicit statement of a problem, tied to observation and to
  - ✓ proof by experiment.
  - ✓ Testing and/or criticism of a hypothesis using
  - ✓ experimentation.
  - ✓ Interpretation of data and formulation of a conclusion using mathematics.
  - ✓ The publication of the findings.

- Show that the ancient emission theory of vision supported by Ptolemy and Euclid (where the eyes emit rays of light), and the ancient intromission theory supported by Aristotle (where objects emit physical particles to the eyes), were both wrong.

Ibn al-Haytham

- His Book of Optics has been ranked alongside Isaac Newton's Philosophiae Naturalis Principia Mathematica as one of the most influential books in the history of physics.
- Ibn Al-Haytham gave the first clear description and correct analysis of the camera obscura.
- Discovered Fermat's principle of least time, and early ideas relating to inertia.
- Discovered the concept of momentum (part of Newton's second law of motion).

Ibn al-Haytham

- Described the attraction between masses and was aware of the magnitude of acceleration due to gravity at a distance.
- Discovered that the heavenly bodies were accountable to the laws of physics.
- His optical research laid the foundations for the later development of telescopic astronomy, as well as for the microscope.
- In geometry, Ibn al-Haytham developed analytical geometry and established a link between algebra and geometry.

Ibn al-Haytham

- Ibn al-Haytham also discovered a formula for adding the first 100 natural numbers (which may later have been intuited by Carl Friedrich).
- Ibn al-Haytham used a geometric proof to prove the formula.
- His contributions to number theory includes his work on perfect numbers.
- Ibn al-Haytham also employed **scientific skepticism** and emphasized the role of **empiricism**.

Ibn al-Haytham

- criticized Aristotle for his lack of contribution to the method of induction, which Ibn al-Haytham regarded as superior to syllogism, and he considered induction to be the basic requirement for true scientific research.
- The concept of **Ockam's razor** is also present in the Book of Optics.
- For example, after demonstrating that light is generated by luminous objects and emitted or reflected into the eyes, he states that therefore "the extramission of [visual] rays is superfluous and useless".

Ockam's Razor

- Commonly attributed to William of Ockham (1290--1349). : Entities should not be multiplied beyond necessity.
- Commonly explained as: when have choices, choose the simplest theory.
- Bertrand Russell: ``It is vain to do with more what can be done with fewer."

Ibn al-Haytham

- He was also the first scientist to adopt a form of positivism in his approach, centuries before a term for positivism was coined.
- He wrote that "we do not go beyond experience, and we cannot be content to use pure concepts in investigating natural phenomena", and that the understanding of these cannot be acquired without mathematics.
- After assuming that light is a material substance, he does not discuss its nature any further but confines his investigations to the diffusion and propogation of light.
- The only properties of light he takes into account are that which can be treated by geometry and verified by experiment.

Nature Of research - Positivist

- Deals with positive facts and observable phenomena
- Subscribes to the 'scientific method'
- Primary goal is not only description but prediction and explanation.

Nature Of research - Positivist

- Classification of substances and events, and observation of these, provide the basis for descriptive laws based on consistencies in patterns and properties Characterized by absolute or varying degree of generalisability
- **Quantitative, as it draws on measurable evidence**

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Postulates In Positivist Research

- Postulate of **natural kinds**: all instances of classes and categories of phenomena exhibit the same properties.
- Postulate of **constancy**: all phenomena remain the same or change only very slowly over time
- Postulate of **determinism**: there is orderliness and regularity in nature, constancy in terms of cause and effect

The Modern Methodology

➢ **Objectives:**

After completing this topic, you should be able to:-

- ✓ Identify the Modern Scientific Methods.
- ✓ Identify the Modern Philosophers and Scientists views about the Scientific Methods.
- ✓ Identify the Modern views of methodology.
- ✓ Identify how to test the Scientific Theories by applying the Scientific Methods.

The Modern Methodology

- **Lessons covered in this topic:-**

✓ Galileo Galilei.

✓ Rene Descartes.

Galileo Galilei

- **Galileo** (1564-1642 AD or CE). Lived in what is today Italy.
- **Galileo** Is considered to be the first true scientist. Why????
  - ✓ Because he actually did the experiment.
  - ✓ Aristotle said that heavy objects fall faster than lighter ones.
  - ✓ So Galileo asked, “How much faster?”
- So he sent students up to the top of a building and had them drop a heavy ball and a lighter one off at the same time. He had other students waiting below to measure the difference in time between the two hitting the ground.

Galileo Galilei

- Today of course we know what happened.
- Much to everyone's surprise both balls hit the ground at about the same time!
- This shows that it is much preferred to test your ideas rather than merely think about them.
- One test is worth a thousand expert opinions.
- When conducting an experiment, change one factor and keep everything else exactly the same. The one thing you change is called the variable.
    - ✓ All the things you keep the same are called controls.

Galileo Galilei

- What was the variable in Galileo's experiment?
  - ✓ The weight of the balls.
- What were some controls?
  - ✓ Dropped from same height.
  - ✓ Dropped at same time.
  - ✓Balls had same shape/size.
- So the theory of gravity, theory of electricity, the germ theory of disease, and the theory of evolution are tested, accepted explanations for events that occur in nature.

Galileo Galilei

- Theories can really never be completely proven, only disproven.
- When new evidence comes along, we must modify our theory or at times even get rid of it and start over again.
- Galileo is considered to be a father of the scientific method.
- Because Galileo thought the way some of his predecessors thought and also anticipated the thinking of some of his successors, his views are of special interest in understanding scientific method.
- He sought respectable authority for his way of establishing conclusions in the writings of ancient Greek philosophers and mathematicians, and there are, too, connections between his ideas and those of his more immediate predecessors and contemporaries in Italy.

Galileo Galilei

- But he also helped to develop the role of experiment, particularly as a useful means for discovering and exploring new connections in nature, and partly because of this we detect in him ideas and methods which were further developed by his successors.
- There is no doubt that his claims about what is true and why it is true were particularly influential in the seventeenth century.
- His ideas played an important part in the early development of scientific method although, as we shall see, the differences between Galileo's views and those familiar to us are at least as significant as the similarities.

Rene Descartes

- Descartes is often regarded as the first modern thinker to provide a philosophical framework for the natural sciences as these began to develop.
- In his **Discourse on the Method** he attempts to arrive at a fundamental set of principles that one can know as true without any doubt.
- To achieve this, he employs a method called hyperbolical/ metaphysical doubt, sometimes also referred to as methodological skepticism:
  - ✓ he rejects any ideas that can be doubted, and then reestablishes them in order to acquire a firm foundation for genuine knowledge.

Rene Descartes

- Initially, Descartes arrives at only a single principle:
  - ✓ **thought exists. Thought cannot be separated from me, therefore, I exist** *(Discourse on the Method and Principles of Philosophy)*.
- Most famously, this is known as **cogito ergo sum** (Latin: "I think, therefore I am").
- Therefore, Descartes concluded, if he doubted, then something or someone must be doing the doubting.
- Therefore the very fact that he doubted proved his existence. "The simple meaning of the phrase is that if one is skeptical of existence that is in and of itself proof that he does exist."

Rene Descartes

- Descartes concludes that he can be certain that he exists because he thinks.
- But in what form?
- He perceives his body through the use of the senses; however, these have previously been proven unreliable.
- So Descartes concludes that the only indubitable knowledge is that he is a ***thinking thing***.
- Thinking is his essence as it is the only thing about him that cannot be doubted.

Rene Descartes

- Descartes defines "**thought**" (*cogitatio*) as "what happens in me such that I am immediately conscious of it, insofar as I am conscious of it".
- Thinking is thus every activity of a person of which he is immediately conscious.
- To further demonstrate the limitations of the senses, Descartes proceeds with what is known as the **Wax Argument**.
- He considers a piece of wax; his senses inform him that it has certain characteristics, such as shape, texture, size, color, smell, and so forth.

Rene Descartes

- When he brings the wax towards a flame, these characteristics change completely.
- However, it seems that it is still the same thing: it is still a piece of wax, even though the data of the senses inform him that all of its characteristics are different.
- Therefore, in order to properly grasp the nature of the wax, he cannot use the senses. He must use his mind.
- Descartes concludes: "**And so something which I thought I was seeing with my eyes is in fact grasped solely by the faculty of judgment which is in my mind**".

Rene Descartes

- In this manner, Descartes proceeds to construct a system of knowledge, discarding perception as unreliable and instead admitting only deduction as a method.
- In the third and fifth **Meditation**, he offers an ontological proof of a benevolent God (through both the ontological argument and trademark argument).
- Because God is benevolent, he can have some faith in the account of reality his senses provide him, for God has provided him with a working mind and sensory system and does not desire to deceive him.

Rene Descartes

- From this supposition, however, he finally establishes the possibility of acquiring knowledge about the world based on deduction *and* perception. In terms of epistemology therefore, he can be said to have contributed such ideas as a rigorous conception of foundationalism and the possibility that reason is the only reliable method of attaining knowledge.
- In Descartes' system, knowledge takes the form of ideas, and philosophical investigation is the contemplation of these ideas.
- This concept would influence subsequent internalistmovements as Descartes' epistemology requires that a connection made by conscious awareness will distinguish knowledge from falsity.

Rene Descartes

- As a result of his Cartesian doubt, he viewed rational knowledge as being "incapable of being destroyed" and sought to construct an unshakable ground upon which all other knowledge can be based. The first item of unshakable knowledge that Descartes argues for is the aforementioned *cogito*, or thinking thing.
- Descartes also wrote a response to skepticism about the existence of the external world.
- He argues that sensory perceptions come to him involuntarily, and are not willed by him.
- They are external to his senses, and according to Descartes, this is evidence of the existence of something outside of his mind, and thus, an external world.

Rene Descartes

- Descartes goes on to show that the things in the external world are material by arguing that God would not deceive him as to the ideas that are being transmitted, and that God has given him the "propensity" to believe that such ideas are caused by material things.
- Descartes was also renowned for his work in producing the Cartesian Theory of Fallacies.
- This can be most easily explored using the statement: "This statement is a lie." While it is most commonly referred to as a paradox.
- the Cartesian Theory of Fallacies states that at any given time a statement can be both true and false simultaneously due to its contradictory nature.

Rene Descartes

- The statement is true in its fallacy.
- Thus, Descartes developed the Cartesian Theory of Fallacies, which greatly influenced the thinking of the time.
- Many would-be philosophers were trying to develop inexplicable statements of seeming fact, however, this laid rumors of such a proposition impossible.
- Many philosophers believe that when Descartes formulated his Theory of Fallacies, he intended to be lying, which in and of itself embodies the theory.

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THANK YOU FOR WATCHING

QUESTIONS?