Course: Foundations of Science Education (695)
Semester: Spring, 2022

ASSIGNMENT No. 1

Q. 1 In which way the Quran, Hadith and Modern Science are related to each other? Argue with suitable examples.

Modern scientific theory today finds itself quite close to the Qur'an. There are at least two reasons behind this observation. The first is the lack of inconsistencies between the Qur'an and observable natural phenomena. Science has not been able to produce theories or experiments that fundamentally contradict the Qur'an. Had our science done so, either our understanding of the Qur'an or of the world would have been to blame: the Qur'an itself is true for all times. The second reason for the remarkable harmony between the Qur'an and science is the presence in the Qur'an itself of very clear and positive encouragement to contemplate and investigate the world around us. As the verses quoted above indicate, Allah has not forbidden man to question, and in fact, it seems He wants us to do so. However, the Qur'an goes beyond simply encouraging all human beings to be aware of the natural world. It also contains widely dispersed references on a variety of subjects which are not only scientifically accurate, but in some cases, quite advanced relative to the time of the Prophet Muhammad (P.B.U.H&H.P). For the Muslim who reads and understands these references, they serve to strengthen his or her faith of course. For the non-Muslim who questions the authenticity or authorship of the Qur'an, these references provide some interesting answers. One possible reason for these Qur'anic verses which describe the natural world can be found in the following verse:

[41:53] soon will we show them Our Signs in the (farthest) horizons, and within themselves, until it becomes manifest to them that it is the Truth...

The historical event which this verse alludes to is the conquest of Makkah. However, almost every verse in the Qur'an carries a historical and a universal meaning, and therefore one possible interpretation of this verse is that it refers to the gradual discovery of greater and greater natural "evidence" of the Creator's involvement in our world. Two of the most important and most fascinating goals of modern science are to peer farther and farther out to the edge of the universe, and to look deeper and deeper into the structure of the human body. It is in these two areas that we find the "signature" of Allah's creative power at its strongest.

"The Qur'an, Knowledge, & Science"

The Description of Knowledge in the Qur'an and by the Prophet (P.B.U.H&H.P)

There are plenty of references to knowledge and the pursuit of knowledge in the Qur'an. The general feeling they leave the reader with is that the possessor of knowledge or wisdom has been given a very powerful gift, and that the pursuit of knowledge is something which should be done actively by everyone. Here are a few verses on the subject:

[96:1-5] Read! In the name of your Lord who created - Created the human from something which clings. Read! And your Lord is Most Bountiful - He who taught (the use of) the Pen, Taught the human that which he knew not.

These five verses make up the first passage revealed from the Qur'an to mankind through the Prophet Muhammad (P.B.U.H&H.P). It is interesting that of all the things which Allah chose to begin His revelation with is related to the actions of reading and writing, especially the latter. The ability to write and store information is described by Professor Carl Sagan in his book COSMOS: "Writing is perhaps the greatest of human inventions, binding together people, citizens of distant epochs, who never knew one another. Books break the shackles of time, proof that humans can work magic." [Davies, Paul. The Cosmic Blueprint. Simon & Schuster, New York, 1988]

[2:269] He [Allah] grants wisdom to whom He pleases; and he to whom wisdom is granted indeed receives a benefit overflowing. But none will grasp the Message except men of understanding. [20:114] High above all is Allah, the King, and the Truth. Do not be in haste with the Qur'an before its revelation to you is completed, but say, "O my Sustainer! Increase my knowledge." [3:190-191] Verily in the creation of the heavens and the earth, and the alternation of night and day - there are indeed signs for men of understanding; Men who remember Allah, standing, sitting, and lying down on their sides, and contemplate the creation of the heavens and the earth (with the thought) "Our Lord! Not for nothing have you created (all) this. Glory to You! Give us salvation from the suffering of the Fire."

These verses are a clear demonstration that 'science' and 'religion' were NOT meant to be fundamentally incompatible with each other by Allah. In fact, verses [3:190-191] strongly imply that "contemplating" the world around us is an integral part of faith.

[29:20] Say: Travel through the earth and see how Allah originated creation; so will Allah produce the second creation (of the Afterlife): for Allah has power over all things.

There are also references in the Qur'an describing the value (in the sight of Allah) of a knowledgeable person as opposed to an ignorant person. They are not equal:

[39:9] ...Say: Are those equal, those who know and those who do not know? It is those who are endued with understanding that remember (Allah's Message).

[58:11] ...Allah will raise up to (suitable) ranks (and degrees) those of you who believe and who have been granted knowledge.

The first source of Islam is the Qur'an - and we have seen some verses above on the subject of knowledge. The second source is the life of Prophet Muhammad (P.B.U.H&H.P).

Q. 2 Explain the role of some eminent Muslim intellectuals in the development of different branches of science.

Science in the medieval Islamic world was the science developed and practised during the Islamic Golden Age under the Umayyads of Córdoba, the Abbadids of Seville, the Samanids, the Ziyarids, the Buyids in Persia, the Abbasid Caliphate and beyond, spanning the period roughly between 786 and 1258. Islamic scientific achievements encompassed a wide range of subject areas, especially astronomy, mathematics, and medicine.

Other subjects of scientific inquiry included alchemy and chemistry, botany and agronomy, geography and cartography, ophthalmology, pharmacology, physics, and zoology.

Medieval Islamic science had practical purposes as well as the goal of understanding. For example, astronomy was useful for determining the Qibla, the direction in which to pray, botany had practical application in agriculture, as in the works of Ibn Bassal and Ibn al-'Awwam, and geography enabled Abu Zayd al-Balkhi to make accurate maps. Islamic mathematicians such as Al-Khwarizmi, Avicenna and Jamshīd al-Kāshī made advances in algebra, trigonometry, geometry and Arabic numerals. Islamic doctors described diseases like smallpox and measles, and challenged classical Greek medical theory. Al-Biruni, Avicenna and others described the preparation of hundreds of drugs made from medicinal plants and chemical compounds. Islamic physicists such as Ibn Al-Haytham, Al-Bīrūnī and others studied optics and mechanics as well as astronomy, and criticised Aristotle's view of motion.

During the Middle Ages, Islamic science flourished across a wide area around the Mediterranean Sea and further afield, for several centuries, in a wide range of institutions.

The Islamic era began in 622. Islamic armies eventually conquered Arabia, Egypt and Mesopotamia, and successfully displaced the Persian and Byzantine Empires from the region within a few decades. Within a century, Islam had reached the area of present-day Portugal in the west and Central Asia in the east. The Islamic Golden Age (roughly between 786 and 1258) spanned the period of the Abbasid Caliphate (750–1258), with stable political structures and flourishing trade. Major religious and cultural works of the Islamic empire were translated into Arabic and occasionally Persian. Islamic culture inherited Greek, Indic, Assyrian and Persian influences. A new common civilisation formed, based on Islam. An era of high culture and innovation ensued, with rapid growth in population and cities. The Arab Agricultural Revolution in the countryside brought more crops and improved agricultural technology, especially irrigation. This supported the larger population and enabled culture to flourish. From the 9th century onwards, scholars such as Al-Kinditranslated Indian, Assyrian, Sasanian (Persian) and Greek knowledge, including the works of Aristotle, into Arabic. These translations supported advances by scientists across the Islamic world.

The Abbasid Caliphate, 750–1261 (and later in Egypt) at its height, c. 850

Islamic science survived the initial Christian reconquest of Spain, including the fall of Seville in 1248, as work continued in the eastern centres (such as in Persia). After the completion of the Spanish reconquest in 1492, the Islamic world went into an economic and cultural decline. The Abbasid caliphate was followed by the Ottoman Empire (c. 1299–1922), centred in Turkey, and the Safavid Empire (1501–1736), centred in Persia, where work in the arts and sciences continued.

Alchemy and chemistry

Main article: Alchemy and chemistry in the medieval Islamic world

The early Islamic period saw the establishment of theoretical frameworks in alchemy and chemistry. The sulfur-mercury theory of metals, first found in pseudo-Apollonius of Tyana's Sirr al-khalīqa ("The Secret of Creation",

c. 750–850) and in the writings attributed to Jabir ibn Hayyan (written c. 850–950),[7] remained the basis of theories of metallic composition until the 18th century. The Emerald Tablet, a cryptic text that all later alchemists up to and including Isaac Newton saw as the foundation of their art, first occurs in the Sirr al-khalīqa and in one of the works attributed to Jabir. In practical chemistry, the works of Jabir, and those of the Persian alchemist and physician Abu Bakr al-Razi (c. 865–925), contain the earliest systematic classifications of chemical substances. Alchemists were also interested in artificially creating such substances. Jabir describes the synthesis of ammonium chloride (sal ammoniac) from organic substances, and Abu Bakr al-Razi experimented with the heating of ammonium chloride, vitriol, and other salts, which would eventually lead to the discovery of the mineral acids by 13th-century Latin alchemists such as pseudo-Geber.

Astronomy and cosmology

Astronomy became a major discipline within Islamic science. Astronomers devoted effort both towards understanding the nature of the cosmos and to practical purposes. One application involved determining the Qibla, the direction to face during prayer. Another was astrology, predicting events affecting human life and selecting suitable times for actions such as going to war or founding a city.[13] Al-Battani (850–922) accurately determined the length of the solar year. He contributed to the Tables of Toledo, used by astronomers to predict the movements of the sun, moon and planets across the sky. Copernicus (1473-1543) later used some of Al-Battani's astronomic tables.[14]

Al-Zarqali (1028–1087) developed a more accurate astrolabe, used for centuries afterwards. He constructed a water clock in Toledo, discovered that the Sun's apogee moves slowly relative to the fixed stars, and obtained a good estimate of its motion[15] for its rate of change.[16] Nasir al-Din al-Tusi (1201–1274) wrote an important revision to Ptolemy's 2nd-century celestial model. When Tusi became Helagu's astrologer, he was given an observatory and gained access to Chinese techniques and observations. He developed trigonometry as a separate field, and compiled the most accurate astronomical tables available up to that time.

Botany and agronomy

The study of the natural world extended to a detailed examination of plants. The work done proved directly useful in the unprecedented growth of pharmacology across the Islamic world. Al-Dinawari (815–896) popularised botany in the Islamic world with his six-volume Kitab al-Nabat (Book of Plants). Only volumes 3 and 5 have survived, with part of volume 6 reconstructed from quoted passages. The surviving text describes 637 plants in alphabetical order from the letters sin to ya, so the whole book must have covered several thousand kinds of plants. Al-Dinawari described the phases of plant growth and the production of flowers and fruit. The thirteenth century encyclopedia compiled by Zakariya al-Qazwini (1203–1283) – ʿAjā'ib al-makhlūqāt (The Wonders of Creation) – contained, among many other topics, both realistic botany and fantastic accounts. For example, he described trees which grew birds on their twigs in place of leaves, but which could only be found in the far-distant British Isles.[19][18][20] The use and cultivation of plants was documented in the 11th century by Muhammad bin Ibrāhīm Ibn Bassāl of Toledo in his book Dīwān al-filāha (The Court of

Agriculture), and by Ibn al-'Awwam al-Ishbīlī (also called Abū l-Khayr al-Ishbīlī) of Seville in his 12th century book Kitāb al-Filāha (Treatise on Agriculture). Ibn Bassāl had travelled widely across the Islamic world, returning with a detailed knowledge of agronomy that fed into the Arab Agricultural Revolution. His practical and systematic book describes over 180 plants and how to propagate and care for them. It covered leaf- and root-vegetables, herbs, spices and trees.

Geography and cartography

The spread of Islam across Western Asia and North Africa encouraged an unprecedented growth in trade and travel by land and sea as far away as Southeast Asia, China, much of Africa, Scandinavia and even Iceland. Geographers worked to compile increasingly accurate maps of the known world, starting from many existing but fragmentary sources.[22] Abu Zayd al-Balkhi (850–934), founder of the Balkhī school of cartography in Baghdad, wrote an atlas called Figures of the Regions (Suwar al-aqalim).[23] Al-Biruni (973–1048) measured the radius of the earth using a new method. It involved observing the height of a mountain at Nandana (now in Pakistan).[24] Al-Idrisi (1100–1166) drew a map of the world for Roger, the Norman King of Sicily (ruled 1105-1154). He also wrote the Tabula Rogeriana (Book of Roger), a geographic study of the peoples, climates, resources and industries of the whole of the world known at that time.[25] The Ottoman admiral Piri Reis (c. 1470–1553) made a map of the New World and West Africa in 1513. He made use of maps from Greece, Portugal, Muslim sources, and perhaps one made by Christopher Columbus. He represented a part of a major tradition of Ottoman cartography.

Mathematics

Islamic mathematicians gathered, organised and clarified the mathematics they inherited from ancient Egypt, Greece, India, Mesopotamia and Persia, and went on to make innovations of their own. Islamic mathematics covered algebra, geometry and arithmetic. Algebra was mainly used for recreation: it had few practical applications at that time. Geometry was studied at different levels. Some texts contain practical geometrical rules for surveying and for measuring figures. Theoretical geometry was a necessary prerequisite for understanding astronomy and optics, and it required years of concentrated work. Early in the Abbasid caliphate (founded 750), soon after the foundation of Baghdad in 762, some mathematical knowledge was assimilated by al-Mansur's group of scientists from the pre-Islamic Persian tradition in astronomy. Astronomers from India were invited to the court of the caliph in the late eighth century; they explained the rudimentary trigonometrical techniques used in Indian astronomy. Ancient Greek works such as Ptolemy's Almagest and Euclid's Elements were translated into Arabic. By the second half of the ninth century, Islamic mathematicians were already making contributions to the most sophisticated parts of Greek geometry. Islamic mathematics reached its apogee in the Eastern part of the Islamic world between the tenth and twelfth centuries. Most medieval Islamic mathematicians wrote in Arabic, others in Persian.

Al-Khwarizmi (8th–9th centuries) was instrumental in the adoption of the Hindu–Arabic numeral system and the development of algebra, introduced methods of simplifying equations, and used Euclidean geometry in his proofs. He was the first to treat algebra as an independent discipline in its own right,[32] and presented the first systematic solution of linear and quadratic equations. Ibn Ishaq al-Kindi (801–873) worked on cryptography for the Abbasid Caliphate, and gave the first known recorded explanation of cryptanalysis and the first description of the method of frequency analysis. Avicenna (c. 980–1037) contributed to mathematical techniques such as casting out nines. Thābit ibn Qurra (835–901) calculated the solution to a chessboard problem involving an exponential series. Al-Farabi (c. 870–950) attempted to describe, geometrically, the repeating patterns popular in Islamic decorative motifs in his book Spiritual Crafts and Natural Secrets in the Details of Geometrical Figures. Omar Khayyam (1048–1131), known in the West as a poet, calculated the length of the year to within 5 decimal places, and found geometric solutions to all 13 forms of cubic equations, developing some quadratic equations still in use. Jamshīd al-Kāshī (c. 1380–1429) is credited with several theorems of trigonometry, including the law of cosines, also known as Al-Kashi's Theorem. He has been credited with the invention of decimal fractions, and with a method like Horner's to calculate roots. He calculated π correctly to 17 significant figures.

Sometime around the seventh century, Islamic scholars adopted the Hindu–Arabic numeral system, describing their use in a standard type of text fī l-ḥisāb al hindī, (On the numbers of the Indians). A distinctive Western Arabic variant of the Eastern Arabic numerals began to emerge around the 10th century in the Maghreb and Al-Andalus (sometimes called ghubar numerals, though the term is not always accepted), which are the direct ancestor of the modern Arabic numerals used throughout the world.

Medicine

Islamic society paid careful attention to medicine, following a hadith enjoining the preservation of good health. Its physicians inherited knowledge and traditional medical beliefs from the civilisations of classical Greece, Rome, Syria, Persia and India. These included the writings of Hippocrates such as on the theory of the four humours, and the theories of Galen. al-Razi (c. 865–925) identified smallpox and measles, and recognized fever as a part of the body's defenses. He wrote a 23-volume compendium of Chinese, Indian, Persian, Syriac and Greek medicine. al-Razi questioned the classical Greek medical theory of how the four humours regulate life processes. He challenged Galen's work on several fronts, including the treatment of bloodletting, arguing that it was effective. al-Zahrawi (936–1013) was a surgeon whose most important surviving work is referred to as al-Tasrif (Medical Knowledge). It is a 30-volume set mainly discussing medical symptoms, treatments, and pharmacology. The last volume, on surgery, describes surgical instruments, supplies, and pioneering procedures. Avicenna (c. 980–1037) wrote the major medical textbook, The Canon of Medicine. Ibn al-Nafis (1213–1288) wrote an influential book on medicine; it largely replaced Avicenna's Canon in the Islamic world. He wrote commentaries on Galen and on Avicenna's works. One of these commentaries, discovered in 1924, described the circulation of blood through the lungs.

Q. 3 Do you agree that Science and Philosophy are inter-reliant? If yes, how? If otherwise, why? Give cogent response.

Philosophy explains, examines and interprets the full meaning of scientific achievements with a view to solving the riddle of the universe as a whole for finding out the key to the 'mystery' to the universe.

Every science deals with a particular department of the universe. It has certain characteristics. They are:-

1. Science is concerned with facts as they appear to us.
2. The methods of science are observation, experiment, classification, analysis, synthesis, deduction and induction.
3. Science accepts a conclusion as true if it stands to reason. Science gives us a comprehensive view of the particular department of the universe. From this standpoint aims of both philosophy and science are identical.

Both science and philosophy aim at reducing the complex fact into a simpler one and bringing the unknown within the known.

Philosophy begins with the conclusion of the various sciences adds to them the results of ethical religious and aesthetic experiences of mankind and reflecting upon the whole so that it can arrive at rational concepts of reality.

Philosophy also harmonizes the inherent truth of different sciences and reduce them to a system. In a time of ascertaining the truth of a proposition both science and philosophy take reason as the only yardstick.

Both science and philosophy aim at organising the synthesizing a harmonious relationship among them. Hence, Philosophy in a sense is the culmination and fulfilment of scientific endeavour.

But in spite of similarities, there are some differences between the two, they are:-

1. Every science deals with a particular department of the world while philosophy deals with the whole universe.
2. Science deals with the material and efficient cause of the universe while philosophy deals with the material, efficient and final cause also.
3. Science deals with the facts only while philosophy deals with the ultimate nature of reality.

But in spite of these differences both science and philosophy are interdependent. Science supplies the data to philosophy for philosophical speculation.

Philosophy takes the results of various scientific investigations and goes beyond them and systematises them as a whole.

Science is isolated from one another unless they are co-ordinate and unified by philosophy. Hence philosophy without science is inadequate and science are incomplete. They are complementary.

Therefore, Weber has rightly concluded the relation between philosophy and science. 'The sciences without philosophy are an aggregate without unity, a body without a soul, philosophy without sciences, is a soul without a body, different in nothing from poetry and its dream'.

Q. 4 Discuss in detail the "Inductive Method" of teaching. What advantages or disadvantages do you observe at secondary level science teaching?

The inductive teaching method is a student-led approach to teaching. In the inductive approach in teaching, teachers provide learners with examples and allow them to arrive at their own conclusions. Discussion and course correction, where necessary, follow this. It's the opposite of the deductive teaching method, where rules are explained first.

The inductive teaching method may not be the most time-efficient way of teaching a subject, as students can go down the wrong path. However, in the long run, it's an excellent way to engage students' analytical abilities and other cognitive functions. For this reason, it's preferred by modern educators.

As we've seen, in the deductive approach, we present a rule to a learner and then they're encouraged to think about it, practice it and learn it. The inductive teaching strategies flow in the opposite direction, being a learner-centric teaching method. Students are presented with facts and then asked to come up with their own rules regarding those. For instance, we might give students five sentences that all contain a past tense verb. They can be asked to identify the verbs and when they should be used. In the deductive approach, we would explain the concept of past tense verb use before moving on to practice work.

What's the purpose of the inductive teaching method? Students could come up with incorrect rules given a set of information. How does that help? The answer is in how it gets them thinking. When we're given information in the deductive teaching method, we are passive receptacles of knowledge. In a teacher-led classroom, a learner's inherent ability to understand and puzzle through information is seldom engaged. In inductive teaching strategies, learners must analyze information in front of them, come up with logical conclusions, and even if they're wrong, the process helps them engage better with the information. It helps them understand the underlying logic in a way that's more memorable.

Advantages Of Inductive Teaching

The inductive teaching model can be powerful in classrooms of all kinds. Let's consider some advantages of the inductive approach in teaching:

- **Promotes Critical Thinking**

  By Not Providing The Answers Upfront To Students, It Invites Them To Come Up With Rules Based On The Information They Have. This Is A Cognitive And Metacognitive Ability That Holds Them In Good Stead In Adult Problem Solving And Decision Making.

- **Engages Student Participation**

  It's Hard To Concentrate In An Environment In Which We Constantly Received Information. The Mind Wanders And Attention Flags. In **Inductive Method Examples**, Group Work Is Often Encouraged, And Students Are Expected To Present Their Work And Findings. It Also Forces Them To Think For Themselves.

- **Learning Is Long Term**

  By Engaging The Brain More Fully, **Inductive Method Of Teaching Examples** Can Help Students Retain Information. Having Puzzled Over Facts And Figures And Other Forms Of Data, Learners Have.

A Closer Relationship With The Subject They're Studying. Even Making Mistakes Can Make Facts More Memorable. The inductive classroom is a lively space where problems are solved, questions asked and mistakes made. Finally, information is learned because of all these processes.

Disadvantages Of The Inductive Approach

Inductive learning might be a popular approach, but there are still situations in which a deductive process is preferable. Here are some disadvantages of the inductive method:

Can Create Inequality

You May See In An **Example Of Inductive** Teaching That Not All Students Will Respond Equally Well, Which Can Create A Lop-Sided Classroom. It Requires An Open Environment Where Errors Are Accepted And Even Welcomed To Be Impactful For All.

Takes Time

Sometimes Students Come Up With Incorrect Hypotheses. It Is Part Of The Process To Work Through These, But There Might Not Always Be Enough Time To Make The Most Of This.

Topic Is Complex

Not All Facts Can Be Reasoned Through. Sometimes, If The Information Is Too Complex, It Is Best To Explain It Upfront. When The **Inductive Teaching Method** Is Employed In The Wrong Place, Students Can Get Frustrated By The Lack Of Progress.

Q. 5 Discuss "Instrumentalism" in the perspective of Science Education.

instrumentalism, in the philosophy of science, the view that the value of scientific concepts and theories is determined not by whether they are literally true or correspond to reality in some sense but by the extent to which they help to make accurate empirical predictions or to resolve conceptual problems. Instrumentalism is thus the view that scientific theories should be thought of primarily as tools for solving practical problems rather than as meaningful descriptions of the natural world. Indeed, instrumentalists typically call into question whether it even makes sense to think of theoretical terms as corresponding to external reality. In that sense, instrumentalism is directly opposed to scientific realism, which is the view that the point of scientific theories is not merely to generate reliable predictions but to describe the world accurately.

Instrumentalism is a form of philosophical pragmatism as it applies to the philosophy of science. The term itself comes from the American philosopher John Dewey's name for his own more general brand of pragmatism, according to which the value of any idea is determined by its usefulness in helping people to adapt to the world around them.

Instrumentalism in the philosophy of science is motivated at least in part by the idea that scientific theories are necessarily underdetermined by the available data and that in fact no finite amount of empirical evidence could rule out the possibility of an alternate explanation for observed phenomena. Because in that view there is no way to determine conclusively that one theory more closely approaches the truth than its rivals, the main criterion for evaluating theories should be how well they perform. Indeed, the fact that no amount of evidence can decisively show that a given theory is true (as opposed to merely predictively successful) begs the question of whether it is meaningful to say that a theory is "true" or "false." It is not that instrumentalists believe that no theory is better than any other; rather, they doubt that there is any sense in which a theory can be said to be true or false (or better or worse) apart from the extent to which it is useful in solving scientific problems.

In support of that view, instrumentalists commonly point out that the history of science is replete with examples of theories that were at one time widely considered true but are now almost universally rejected. Scientists no longer believe, for example, that light propagates through the ether or even that there is such a thing as the ether at all. Whereas realists argue that, as theories are modified to accommodate more and more evidence, they more and more closely approximate the truth, instrumentalists argue that, if some of the best historical theories have been discarded, there is no reason to suppose that the most widely accepted theories of the present day will hold up any better. Nor is there necessarily any reason to believe that the best current theories approximate the truth any better than the ether theory did.

There may nevertheless be a sense in which the instrumentalist and realist positions are not as far apart as they sometimes seem. For it is difficult to say precisely what the distinction is between accepting the usefulness of a theoretical statement and actually believing it to be true. Still, even if the difference between the two views is in some sense only semantic, or one of emphasis, the fact is that most people intuitively do make a distinction between the truth and the practical usefulness of scientific theories.