Üniversite Araştırmaları Dergisi, Aralık 2018, Cilt 1, Sayı 3, Sayfa: 121-131
Journal of University Research, December 2018, Volume 1, Issue 3, Page: 121-131
Özgün Makale / Original Article

How to Improve the Science and Engineering Education in Islamic Countries?

Zekai Şen

İstanbul Medipol University, Engineering and Natural Sciences Faculty, Beykoz 34815, Istanbul, Turkey.

Abstract

The evolutions of science, education and especially engineering training had different trends stating from the very root of human history. The future improvements in scientific and engineering education require extensive literature review to assess objectively the contributions of different civilizations among which Islamic education system had a unique feature in the past towards the researches in astronomy, physics, chemistry, algebra, robotics, medicine, etc. The universities are the highest educational institutions which provide every nation with enlightened individuals; promote intellectual development; advent and promote innovations and discoveries in field and laboratory. Prior to all these activities, it is necessary that the same universities should produce philosophical schools of thought, literature, artistic and social trends. Researchers should be able to put forward theories of good, right and beauty with ideas and orientations that serve as a reference for future policy makers in different sectors for the prosperity of the nation and humanity in general. After long centuries of slackness, the higher education is gaining momentum in the Muslim World which is striving to effect comprehensive developments in the present century. Almost in every aspects of life highly-trained manpower are required. Unfortunately, scientific philosophical thinking and logical refinement of scientific information aspects are missing in almost all the universities in Muslim countries. Especially, three T-principle as Takhayyul (imagination), Tasawwur (design, geometrical shape description) and Tafakkur (idea generation) do exist very rarely in our universities. In fact, the 3-T principle is the trigger of scientific information generation process. This paper elaborates on the education systems during the past Islamic periods, which ignited the educational system development in the western countries; its decline; and the present situation with ever increasing momentum towards the future. It is emphasized that the higher education and scientific research should have philosophy, logic, geometry and natural event visualizations prior to mathematical and computational calculations in engineering education.

Keywords: Education, engineering, Islam, imagination, geometry, logic, philosophy, science.

İslam Ülkelerinde Bilim ve Mühendislik Eğitimini Nasıl İyileştirmeli?

Özet

İnsanlık tarihi kökeninden başlamak üzere bilim, eğitim ve özellikle mühendislik yetiştirilmesi evrimlerinde farklı eğilimler vardır. Gelecekteki iyileştirmeler için değişik medeniyetlerin katkılarını bilim ve mühendislik eğitiminde ayrıntılı literatür araştırması ile değerlendirmek gereklidir ve bunlar arasında İslam eğitiminin geçmişinde kendisine özgü özellikleri astronomi, fizik, kimya, cebir, robatik, tıp, vd. araştırmalar bulunmaktadır. Üniversiteler her ulus için aydın kişilikler yetiştiren, akılları geliştiren, yenilikçi keşifler yaptırabilen ve laboratuvarlarda buluşlarda bulunabilen en yüksek eğitim kurumları arasında gelir. Bütün bu çalışmaların öncesinde aynı üniversiteler filozofik düşünce yetisi, edebiyat, sanat ve sosyal temayüllerde da üretim yapabilmelidir. Araştırıcıların iyi, doğru ve güzel kuram fikirleri ve yönlendirmeleri ile genel olarak insanlığın ve bir ulusun değişik sektörlerinde etkili olabilecek politikaları da ileriye sürmeleri gereklidir. Uzun asırlar durgunluk sonrasında yükesk eğitim Müslüman ülkelerde içinde bulunduğumuz yüz yıllarda kapsamlı bir şekilde momentum kazanmaktadır. Nerede ise hayatın bütün konularında yüksek eğitim almış iş gücü talep edilmektedir. Maalesef, felsefik bilimsel düşünce ve bunların mantık ile inceden inceye süzülmüş bilgi konuları nerede ise bütün Müslüman ülkelerin üniversitelerinde pek bulunmamaktadır. Özellikle, Tahayyül (hayal etme), Tasavvur (şeklini zihinde canlndırma) ve Tefekkür (bilgi üretimi) konuları bu üniversitelerde pek yoktur. Gerçekte, bu 3-T ilkesi bilimsel bilgi üretim sürecini tetikler. Bu makale geçmiş zamanlarında İslam eğitim örgünlüğününü ve bunun Batı ülkelerindeki eğitim örgünlüğünü kıvılcımlayarak geliştiği konusunda bilgi vererek daha sonra neden gerilediği ve bugün gelecek için nasıl bir momentum göstermesi konularını ayrıntılı olarak açıklar. Yüksek eğitimde bilim felsefesi, mantık kuralları, geometri (şekil bilgisi) ve olguların zihinde canlandırılması konularının matematik ve bilgisayar programlamaları öncesinde mühendislik eğitiminde bulunmasını kuvvetle tavsiye eder.

Anahtar kelimeler: Eğitim, mühendislik, İslam, hayal etmek, şekil bilgisi, mantık, felsefe, bilim

1. INTRODUCTION

It is a fundamental question today whether the political power in Islamic countries strive for the wisdom or politically provide education facilities to the people for their daily and future practices of life for earning material and position towards the betterment of central administration and concentration of power. In the early centuries of Islamic enlightenment from 8th to 13th century, the Muslims developed unprecedented educational systems

*Yazışma Adresi / Address for Correspondence:
Zekai Şen, Email: zsen@medipol.edu.tr

Geliş Tarihi / *Received Date:* 18.11.2018
Kabul Tarihi / *Accepted Date*: 14.12.2018

Doi: 10.26701/uad.484662

as Madrasah (University) along with the religious aspirations, but later they become more interested in hereafter affairs neglecting the worldly transactions especially in science and technology. This is mainly due to the losing ground of philosophical thinking and consequent logical dynamic wisdom affairs. Throughtout the Islamic history all the knowledge based information generation are referred to as "ilm", which included not only the so called positivistic thoughts and education system but additionally the spiritual and metaphysical aspects of the life are also incorporated in it. Unfortunately, in the Islamic word there has been shift towards the Western style of knowledge and information understanding, and therefore, away from the Islamic principles the word of "Science" is adapted and especially in Turkey for the last 40-50 years "ilim" is kicked out of cultural thinking bases and instead positivistic concepts under the word of "science" and in Turkish "Bilim" came into existence. This brought the false conception of technological development, which has been initially triggered by Muslim thinkers prior to Renaissance.

After the 17th century, Islamic states urged for the transfer of western knowledge and technology in military domain whereas the education system became dominated by theological training only. Even though the early prototypes of modern universities have the flavor of Islamic Madrasah system that has been converted to modern research institutions in the west, unfortunately, now days, all Islamic countries try to duplicate the western university system for knowledge generation only through imitative patterns rather than self-cultural intermingling of the wisdom with historical heritage that comes from 8th to 13th centuries. On the other hand, today the Western educational systems strive for the Old Greek philosophers and thinkers before Christ era by completely ignoring modern and developed era of Islamic knowledge, information, enlightenment, and education system. Even though Islamic scholars, philosophers, astronomers, mathematicians, chemists, physicist, pharmacies have poured their original ideas especially to the West, but the westerners preferred to base their scientific and technological development foundations on Old Greek and Hellenistic scripts. It is, therefore, necessary to empower the Muslim youth for scientific and technological ambitions with their common Islamic culture of science and technology so that they can feel encouragement for innovative mental activities. Of course, this does not mean that they must ignore other cultural contributions in science and technology as their forefathers translated Old Greek, Hellenistic, Indian and other cultural accumulations in science and technology first to Arabic language so that every Muslim could benefit from the worldly knowledge. Today, there should be historical account of the scientific foundations and technological developments with the Islamic realities on fair grounds without preconditioned ideas that the religion is against the science especially by considering Noble Qur'an, Hadith and Islamic intellectual traditions.

Another deficiency in the Muslim researchers and teachers is not to criticize the Western science objectively based on the scientific criteria, but rather to imitate and memorize these scientific fundamentals without any criticism in the form of inferiority complexity feelings. It is possible to study modern science from Islamic philosophical foundations point of view focusing on scientific aspects. It is not helpful to throw slogans of any type but rather to base a positive Islamic critique on pros and cons of modern science. Muslims must be able to maintain the traditional Islamic intellectual space for the legitimate continuation of the Islamic view of the nature of reality to which Islamic ethics correspond, without denying the legitimacy of modern sciences (Nasr, 1998).

Unfortunately, in Islamic countries most of the politicians praised the Western science without any criticism for the betterment of their positions with some ethical, cultural and especially religious sayings in between the lines. Their directions were towards an adoption for a rapid and complete absorption of modern Western science without any hesitation and scientific criticism. In fact, the modern science is adopted in a worship-like attitude by Muslim masses without ignition of their creative wisdom for invention or discovery of innovative technological or scientific ends. Of course, this is due to the inferiority complex, which is embedded within Islamic societies and this ill situation cannot be erased by Western science and technology but with the critical assessment of the history of science and by knowing the numerous contributions that contributed to form the foundations of the modern science by Muslim scholars who not only translated and transferred the Old Greek and Hellenistic wisdom but empowered them by new foundations, which were handed down to Western society. The Muslim societies should try any re-discover their own renaissance prior to the renaissance in the West. Such an authentic Islamic science and technology perspective can help to overcome the inferiority complex, which is widespread among the so-called Muslim scholars and intelligentsia today. The students enter the university circles with the hope that they may overcome their inferiority complex, but the inferiority complex of staff members drive them towards obedience of dogmatic scientific knowledge, information and acceptance of the technological apparatus as guided robots.

In the past, Muslims attached unnecessary significance to engineering and medical studies ignoring basic sciences where the scientific and technological developments ignited the soul of inventions and discovery. It is, therefore, necessary to allow a sufficient number of Muslim students to study on the highest level of the modern sciences especially the basic sciences which are called in the West as pure science. The importance in the development of

science and technology is not in the mechanical and robotic-wise training and education, but to be conscious that what the researcher does must be of some utility in practical life through applications even though it may be crumbs of science and technology. In many Islamic countries the power is in the hands of those who advocate every aspects of modern science, but it is sad that the general quality and product of education has declined in almost every field during this century. Many research institutions and universities are just for filling the gaps of high demand for university education and keeping statistics high that so much educated people is available in the society. In some Islamic countries, the empowered patrons are engaged with the increase of the university or high school numbers leaving aside the quality improvements and quality control. Parallel to this movement there is also the trend to send as many students as possible to Western universities at any cost again without any quality control because the importance is in the holding of a certificate from a Western university, but not vital and dynamic basic scientific and technological developments. Even though among them who become scientifically and technologically champions in their areas cannot find good quality students for generating research and development within their native countries, because all distinguishable minds seek a scholarship and try to travel to a Western university even though the university that they enter may be less recognized than their native universities. This is the idea that is embedded in daily thinking philosophy of the youth and with education from a Western university he/she gets the highest respect in the native universities and societies at large.

2. PHILOSOPHY

Every human desire agitates the mind and distracts the process of concentration indispensable for an act of understanding to be productive. The stronger an emergent desire, the higher the degree of agitation it stirs up; the less the degree of concentration of mind; and the less the degree of concentration; the fuzzier the process of thinking, the lower the degree of understanding. Most of the desires self-propel their intensity - the more one tries to satisfy them, the higher become the demand; the way of moderation - the 'middle way' as in the Hadith of Prophet Mohammad (pbuh), is hard to follow when the fire of desires is burning inside us and making the minds restless, turbulent and obstinate. Amidst of such feelings the human mind is completely free in thinking including every extreme towards any direction. This is referred to as the philosophical thinking, which must be filtered later through the logic rules for deducing proper, meaningful and useful statements (arguments) leading to plausible conclusions.

The restlessness and turbulence of minds are permanently intensified by the stress in which one lives due to the competitiveness inherent today and the helplessness of majority of us to get out of the social boxes and cages (in which we have been pushed by economic forces too strong to be withstand), even if we desperately desire to.

Although the strength of passion with which we pursue truth and understanding is a powerful stimulator and 'energizer' of thinking, understanding needs 'peace of mind' - a mind, which is calm and cool, composed and collected.

Paradoxically enough, while being sources of fuzziness, mind and desires are, at the same time, key factors for overcoming (transcending) it, especially if it relates to problems deeply rooted in human experience.

The fuzzy concepts in understanding problems that emerge out of life complexity as, it unfolds, cannot be resolved at the same level of knowledge that we have when these problems appear. When our consciousness is expanded i.e. raised to a higher level, then the tension fades and the problems being seen in a new light are no longer problems. When problems dissolve, we say that the fuzziness related to them has been transcended. There is also a need to relate mind operations to design educational system possibly by taking the attention to the difference between mind and intelligence. Consideration of intelligence only may lead to westernized idea prompts for technological achievements. However, many souls are also striving to have a society with moral and cultural aspects of the life emulated in the education system; where rather than intelligence mind functions must be activated.

The qualitative jump of consciousness to higher-levels results in transcending the fuzziness. As far as consciousness is a holistic characteristic of human, and perhaps not just of human, nature and not only a product of mind, its growth and transformation are possible when the factors responsible for the integrity of all three inseparable constituents of human individuality, which are body, mind and soul, become simultaneously activated. This simultaneous activation ('firing') is referred to as a consciousness resonance and hence

"*The fuzziness of understanding can be transcended when the consciousness resonance occurs.*"

The consciousness resonance is a resonance of all factors responsible for human integrity as manifested in the holistic nature of consciousness. What are these factors? First, factors, which contribute in keeping human body healthy and human, mind capable to think and decide, no matter what kind of logic it prefers - fuzzy, binary, inductive, deductive, abdicative, etc. However, these factors are not enough the consciousness resonance cannot occur when neglecting the soul factors; we can name some of them as sensitivity and responsiveness, awareness and ability to stay awake, passionate desire to get out of the 'attractor' of egocentric thoughts and desires, compassion and love, willingness to explore more subtle and spiritual dimensions of reality and to share with others skill,

knowledge and wisdom.

The philosophy of fuzzy thinking is based on graded concepts. It is a concept in which everything is a matter of degree, i.e. everything has softness (elasticity). The fuzzy logic theory has been given first in its present form through the early publications of Lotfi Asker Zadeh (1973). He wanted to generalize the traditional notion of a set and a statement to allow the grades of memberships and truth values, respectively. These efforts are attributed to the complications that arise during physical modeling of real world. These are,

1. Real situations are not crisp and resolute; hence they cannot be described precisely.
2. The complete description of a real system often would require by far more detailed data than a human being could ever recognize simultaneously, process and comprehend.

The last statement Zadeh calls the *principle of incompatibility*. Its message is that the closer one looks at a real-world problem, the fuzzier becomes its solution.

3. HUMAN MIND

Human beings are created to think and take decision for their daily life activities towards the prosperity. They are even referred to as "clever animals", which can judge the circumstances and reach the purpose whatever it may be. Five sense organs provide information from the surrounding environment of the men and accordingly the decisions are taken after the logical and rational judgments. However, since the origin of life for many millions of years, the judgments are internally processes by human mind and results are put out.

Our mind is the generator of fuzzy impressions and conceptions. It divides the seeable environmental reality into fragments and categories, which are fundamental ingredients in classification, analysis and deduction of conclusions after the labeling each fragment with a "word" such as a name, noun or adjective. The initial labeling by words is without any motion and without interrelation between various categories. These words have very little to do with the wholeness of reality - a wholeness to which all of us belong inseparably. Hence, common words help to imagine the same or very similar objects in our minds. Furthermore, the real world that is pieced together from fragments, which are made from sensations, thoughts and perceptions. They serve collectively to provide partial and therefore distorted conceptual models of reality, which represent a perceived, a human-mind-produced world.

The mind confronts with dilemma or duality and hence it either selects something while rejecting its opposite. This trains the mind in black and white crisp thinking as a first approximation to model the reality. Such a distorted model of reality based on duality is referred to crisp or binary logic the foundations which was established by Aristotle who lived around the third century before Christ. Although prior to Aristotle human mind was based only on natural and innate logical principles, but it became restrictive with the duality principle preference. The dualistic nature of rational reasoning component of mind is so strong that mind alone is unable to transcend it; the best it can do is to reconcile the opposites. Hence the crisp logic, there is no vagueness, ambiguity, possibility or probability because everything is either white or black. Classical black-and-white approach in thinking can easily entrap human mind in routines, stereotypes, prejudices and habits that become a source of fuzziness, which eventually makes one incapable for authentic experience. This is because all our 'understanding' is constantly filtered through already establish mental patterns. Fanaticism is an extreme manifestation of this kind of dense fuzziness, when human ability to move beyond an established dogma is entirely blocked.

On the other hand, even today human beings have vague, ambiguous, uncertain, possible and probable concepts and approaches towards our daily affairs. This natural logic is wider and more general than the crisp logic, and therefore, it is labeled as fuzzy thinking when using fuzzy or probabilistic reasoning, where it is possible to accept both the opposites up to some degree of belongingness. By following the fuzzy logic-based approach in thinking one can agree with everything the others say and this can easily push us towards compliance and indecisiveness. When everybody is right, the uncritical acceptance of the fuzziness accompanying other people's thoughts makes it hard for one to generate his own creative ideas. The polarity of opposites, contradictions and clashes of opinions provides human mind with dynamics necessary for transcending the opposites.

For creative research with fruitful and innovative conclusions one is advised to be able to go beyond the established classical logical rules and restrictions no matter how soft (fuzzy, probabilistic) or hard (crisp, binary, deterministic) the concerned phenomena are.

The fuzziness of knowing never ceases to exist. This is a paramount characteristic of the human knowing, which challenges humanity and constantly propels its search for truth and understanding the secrets of reality.

4. LOGIC AND RULES

The origin of the word "logic" is derived from Greek, which means what is spoken through the arguments. The main objective is to distinguish rational from irrational arguments and discussions leading to newly born scientific information. In most Islamic countries it is "mantiq", which means rational talk with beneficial informative conclusions. Logical thinking in search of rational conclusions, algorithms, procedures, methodologies and even software writings is the most essential brain activity that is necessary in any educational system for innovative idea

generations. Philosophy is the collection of any rational, irrational, complex, sophisticated and insoluble knots of thoughts, but logic filters these ideas of ocean with conclusive rational, objective, general and selective information. To achieve innovative ideas logical thinking should be based on the etymologic and epistemological information context. These ingredients help to generate new ideas that are acceptable objectively by everybody for some time, until to their logical improvements. Logic also exposes human reasoning prescriptions that are implementable for automation to machines such as computers and robots. It is said that mathematics is logic and without logical rules one cannot write software even in his/her specialization domain. Mathematics is based on the symbolic codification of the logical principles in forms of equations. Logical thinking cannot be defined as sole crisp (deterministic) rules, but for further developments its bases include also approximate reasoning, probability and recently fuzziness.

Logic searches for the meaningful sentences among many sentences in a text or paragraph. Not all the sentences have logical structure and only logical sentences lead to thinking, interrelationship existence between various categories and deduction of a final decision. It is, therefore, necessary to have some guidelines for the identification of logical statements in a given text or to construct them in the thinking process about some phenomenon.

Present education systems are rather classical with extensive dependence on crisp and blueprint type of information. In many institutions almost, spoon fed knowledge and information loadings on fresh brains are experienced without creative or functional productivities. This is perhaps one of the main reasons why in many institutions all over the world, creative and analytical thinking capabilities are not advanced. Of course, it is easy to criticize the quality of students, but the view taken in this book is that the quality of staff member should also be improved. In developing countries, it is thought most often that the quality control can be improved through the improvement of students' quality only, which is a defective approach, since highly qualified staff members may lead to improvements in students' quality whereas the reverse is not true. In classical systems, more than basic logical propositions, formulations and determinism are mentioned for the solution of problems. Especially, in hydrological sciences almost each field study at a site is completely different from other sites even though they may be geographically close to each other. Therefore, determinism or crisp information systems cannot be valid for the description of phenomena concerned. Additionally, for revival of golden Islamic scientific and technological era interactive education system with basic scientific philosophy and especially logic bases must be considered without ignorance of science history, which is the main golden achievement period after the "Happiness Centuries", i.e. "Asr-ı Saadet".

It is stated in this book that rather than crisp information and solution techniques, as a first step in any hydrologic system, FL fundamentals must be provided, because it is the natural logic which has been forgotten unfortunately, due to continuous classical logic training. Prior to any equation proposition or verification by data, FL concepts may lead to general solution of the problem. In a FL hydrologic training the causes of a phenomenon must be identified as variables and then these variables are considered as sub-categories, which are then combined through logic propositions to each other.

The main conclusions are that hydrologic knowledge cannot be completely verifiable or falsifiable but rather it is always fuzzifiable which provides potentiality for further researches. As a general conclusion of this book, it is assessed that the hydrological sciences will not be completely verifiably or falsifiable but always fuzzifiable and hence further developments in the form of prescience, traditional science and occasional revolutionary science will be in view for all times, spaces and societies (Kuhn, 2000).

Throughout the history, different cultures and nations have contributed to technological developments under their prevailing social, religious, philosophical and scientific environments. The more the philosophical enlightment in a society, the better is the rational thinking and technological contributions. Primitive technological developments, in the roots of the historical origins of men, can be identified through the single body of information that lies in the vast body of excavation reports prepared by numerous archeologists. One must rely on bits of pieces unearthened during the careful excavations. Another source of information lies in the pictures drawn by artists in antiquity. These may be widely differing kinds such as wall paintings, mosaic pavements or pictures painted on pottery. For example, there are plenty of pictures of Mesopotamian monarchs hunting lions and conducting military campaigns, but unfortunately for the humbler crafts there is an extraordinary blank (Hodges, 1970). These are concerned mainly with the period of history prior to the invention of scripts. However, the technological developments of larger scales have been elaborated by successive civilizations and there are written documents. Here, at the one extreme lies the very early clay tablets on which the scripts kept the account of their masters, and, at the other, they have handed down to us the writings of the Greek, Roman and Muslim men of science. For the development of modern technology, clay tablets cannot be regarded as the reservoir of information, because most often they include the number of slaves used in a certain operation, laws that imply on the society and perhaps the writs of rulers for different purposes.

As the ability to read and write became more widespread, so more and more records became available which are pertinent to technological subjects, until there emerged

at last what can best be called workshop recipes, often quite detailed, giving, for example, the formulation of a glass, stating not only the materials to be used but also the processes to be followed. Such sources of information accumulate through the years and provide a common basis for those who would like to make further advancements towards better technological horizons. Unfortunately, in the history since the communication facilities were not fast and sufficient enough; most of these written documents have not spread but remained in the shelves for many centuries. One question that comes is whether mankind could improve technological gadgets earlier in the history, had it been that this information was connected to each other in the sequence of time. It is obvious from the discussion in this paper that such a continuous process in the technological evolvement has not taken place in different parts of the world. Recent studies indicate that some of the technologies, that are alleged to be originated in a certain location, culture and time, have been indeed developed in other foreign societies many centuries ago. Hodges (1970) has accounted in detail various technological developments in different parts of the western world, but he has ignored, unfortunately, clear majority of the eastern developments towards technology. Another point that he raised in his book is that anything that did not fit the western society has been included under the title of the barbarians. Although, the Islamic technologies have also been included as a subset of barbarian technology by him, this paper will clear out such an unjustifiable allegation with the ingenious mechanical devices which have predated the western industrial revolution at least for 5 centuries. The initial works in the west concerning Al-Jazari have started by Wiedemann and Hauser (1915) and Hauser (1922).

Most of these documents have not been well identified especially in the Islamic civilization which shed flood lights on the classical Greek civilization with introduction to the Western renaissance in many aspects. In this paper, one of the forgotten masterpieces of Muslim technology devices will be illustrated through Al-Jazari hand drawn mechanical systems. He has originated many modern technological concepts but unfortunately due to communation lack, his studies and mechanical devices have not been well recognized until the work by Hill (1974). There onwards many other scholars have studied Al-Jazari's ingenious water devices from different aspects (Sarton, 1950; Al-Hassan, 1977; Şen, 2000; Şen 2013).

5. HISTORICAL PERSPECTIVE

In the western culture the freedom of thought from the pressures of the church and the development of scientific knowledge has been based on the ancient Greek activities. It must be remembered right at this stage that, the Muslim scholars in the North Africa, and especially, in Muslim Spain (Andalusia) have contributed the flux of information and consequent enlightenment in Europe after the 10th century which went on for 5 centuries. During this period even the original classical Greek books and documents by Plato, Aristotle, and others have been translated not directly from Greek language but Arabic, because by that time, the language of scientific thought in the eastern and especially Islamic countries was Arabic. This point has been documented by the pioneering science historian Sarton (1950) that from the 7th to 13th century there is not even a single western thinker, philosopher or scientists' name against many in the Islamic world (Şen, 2013).

Abu-l Iz Al-Jazari who has lived during the 12th century is the father of robotics that worked by water power hydraulically. He has reviewed previous technology developers such as Vitruvius and Heron who have lived during the first few centuries after the Christ in the Roman domain. Unfortunately, they have not left proper designs or procedures for the few technological ideas of their origin, but Abou-l Iz Al-Jazari has drawn many mechanically proper designs in his hand-written book which is printed in its original form by the Cultural Ministry of Turkey in 1990. His book has been translated into English by Hill (1974) with the modern drawings corresponding to the original ones by Al-Jazari. He has lived in the southeastern part of Turkey under the Turkish dynasty of Arthuque Turks that reigned during the 12th century in the region of Diyarbakir which is the greatest city presently in the southeastern Turkey. A glance through his book brings to one's mind the question of who the first man in the human history in visualization was and drawing mechanically usable devices closest to today's technological level. Perhaps, most of us will jump to the conclusion that, if during the very history somebody from the ancient Greek period or if more recently after the renaissance, somebody from the European countries. Unfortunately, such an automatic thinking will lead to error and the true and proveable answer is Abou-l Iz Al-Jazari who lived in the medieval period. It is important to emphasize at this state that medieval period was indeed an enlightenment time for Islamic countries, whereas Europe was living in dark ages as a riddle. Again unfortunately, due to cultural erosion even today in the Islamic countries many will find it hard to believe that a Muslim technologist has devised automatic robots in the 12th century. This is since the Muslims do not care for their prosperous past but mechanically get the documentations from other sources most of which do not reflect the reality (Şen, 2013).

Europe has been in direct conflict and mixing with the eastern countries among which the majority were Muslim societies that reached even Spain and consequently, the information sources from these societies entered the west during many centuries. It is not possible to think that the renaissance came into existence without any friction with Muslim countries that had translated, criticized and improved all the eastern and antique Greek philosophies and way of thinking into Arabic and spread these

ideas among their scholars. One of the lessons that can be withdrawn from this discussion is that science and technology requires as fertilizers the social, economical and religious status of the society. The more convenient these fertilizers, the more the science and technology shift towards these centers. The books of many Muslims have been translated first into Latin then to various languages, and consequently, the public of the country concerned have started to understand the basic information and the establishment of this information between the scholars of the country giving rise to enlightenment for future generations and developments. For this reason, it is necessary to deal with science and technology histories with emphasis to the country's perspectives in the past (Şen, 2013).

Historians of science have sought more narrowly to find the sources of scientific rationality in the arts and crafts, that is, in the prevailing technology and artisan (Weber, 1951). The science and its outgrowth technology have undeniable civilization dimensions as outgoing social activities. Hence, they are neither ethno-centric nor orientlist to speak of the directive structures and institutions that served as the guiding moral, religious and legal frameworks for intellectuals in medieval Islamic civilization, in China, or in the European West (Huff, 1993). During the medieval period symbolic and intellectual discourse were relatively institutionalized and shared to a great extent by informed individuals living in widely scattered places across all the then existing civilizations. Hence, it is not objective scientifically to state that the modern science and technology were products of a single civilization but inter-civilization outcome (Şen, 2013).

It can be stated in the first instance, that the contributions of Islamic civilization to the west made the development of modern science, because this civilization was intermingled with the elements of previous civilization thoughts, philosophies and documents through translations into Arabic that these were conveyed to the West. Among the intermingling civilizations were the civilizations of China, India, Persia and ancient Greek. Especially, prior to the thirteenth and fourteenth centuries the contribution of Islamic civilization to the foundation of knowledge, logic, mathematics, astronomy, and methodology were very significant. Some would say that it was the Greek heritage of intellectual thought, above all its commitment to rational dialogue and decision making through logic and argument that set the course for intellectual development in the West (Needham, 1954). One does not have to subscribe to such a view to recognize the great importance of the Greek tradition to Western science. The larger point is, however, that the modern science is the product of several such sustained inter-civilization encounters over the centuries (Huff, 1993; Şen, 2013).

6. ISLAMIC TECHNOLOGY BEFORE AL-JAZARI

Hill (1974) has given a detailed account about the technological development in the Islamic world before Al-Jazari. In fact, the book of Al-Jazari is regarded as a technological accumulation of the Islamic period. The technological developments by Muslims have not been witnessed in any civilization in the history to the extent that the devices are very illuminating and provide services for many social purposes. This implies that even the roots of the present-day technology owe much to Muslims. They did not only gather the early civilizations' ideas but criticized their opinions for the betterment of the technology and additionally, on this basis they constructed with their original ideas further developments in the technology history. From this respect, Al-Jazari's book is unique in reflecting the then available technological level of humanity.

Sarton(1950) accepts that Muslims have climbed to the climax of the technological developments by the work of Al-Jazari. Unfortunately, then onwards the similar works by Muslims is almost inexistence and they have not given right significance to their works. However, Nasr (1964) has provided the works of medieval Muslims and through his books, there are mentions of old Muslims' technological, philosophical and natural views. The first and far most significant study on Al-Jazari's biography has been given by Wiedemann and Hauser (1915). Consideration of Al-Jazari's book indicates that more than social and historical aspects, he has concentrated on the engineering design. The physical explanations are also included in his writings and in this manner economical, practical and modern approaches have been incorporated in the final production. Even today, the construction of Al-Jazari's devices is possible because he has written in detail to every aspect of the elements and their joint operations in Arabic in an understandable manner.

Before Al-Jazari, there were several Muslim thinkers that gave rise to technological ideas and devices among whom were the Banu Musa brothers, Khwarizmi and Radwan. Banu Musa was a collective name for three brothers as Abo Cafar Mohammad, Abo Qasam and Hassan. After their father's death they were protected by Abbasid vicegerent Al-Ma'mun. The devices produced by these brothers were later modified and used by Al Jazari. Among the works of these brothers were about 100 different devices, 7 of these were fountains, 4 automatic crippling machines, an automatic music instrument, a gas mask for approaching polluted water well and the entire remaining are concerned with water reservoirs of various shapes and sizes. These brothers also considered whatever was available for them from previous researchers, especially Philon and Heron. However, Banu Musa has produced more sophisticated and automatic devices than the previous men (Şen, 2013).

Al-Jazari has used water clock idea of Archimedes. He has completed the missing by Archimedes and produced the first completely working water clock with full elements. Another mechanical element that has been developed by

Muslim researchers is the conic valve that has not been designed by any previous civilization. The conic valve has been used in many different parts of devices in Al-Jazari's book.

On the other hand, Khwarizmi has written a book named Mafatih Al-Ulum (Keys of Sciences) during 971-991 and in this book he has given various automatic devices that have been used by Muslims up to that time. In his book, some sections and paragraphs within sections include mechanical devices or their elements as knowledge. This book includes explicitly all the terminology that has been used by Al-Jazari. Another Muslim scholar who affected Al-Jazari is Fakhreddin Radwan bin Mohammad Al-Saa'ti. Although Radwan was a physician, he was also interested in literature, logic and philosophy. However, his interests in technical aspects were lacking which are clear in his technical drawings. Even though his drawings had missing parts, they were stimulating sources for further Muslim technological developments. Since he was not a technical man, in his book drawings were not given in detail (Şen, 2013).

As there are very faint knowledge concerning Islamic science and technology, water engineer Abou-l Iz Al-Jazari was not well known even though he has left illuminating illustrations of original water machines that are powered by water power only in the 12. Century Modern technology has been assumed in almost all over the world as a product of the western civilization only. However, long before that, many other civilizations such as old Egyptians, Mesopotamians in the practical works and the Muslims as ingenious devices of wisdom have contributed to the development of the modern technology. At least, it is historically evident that such contributions are now appreciable to equitable extent. Hill (1974) has stated that the great Italian engineer Juanello Turriano, who worked and wrote in sixteenth century Toledo, would have been able to inspect the hydraulic works of Muslim predecessors and to draw upon the long tradition of Hipno-Muslim water engineering. It is, therefore, possible to assume Muslim influence on his achievements, although there is no written record to confirm this. Many Muslim ideas eventually found their way into the general vocabulary of European engineering that are justified in believing that most of these were not reinventions, which are rare events in the history of technology, but had been received, directly or indirectly, from the Muslims. Especially, the works of Abou-l Iz Al-Jazari's hand drawn mechanical devices provided visual and intellectual receipts for further development of the technology. Unfortunately, Muslims were not aware of their very rich and prosperous cultural heritages until recently and the works of Al-Jazari have been buried into the history without any notice (Şen, 2013).

6.1 Technology and Al-Jazari

The case of Abou-l Iz Al-Jazari will be emphasized in this paper towards his achievements for automatic mechanical devices that worked with the then available water power mostly and wind power to a little extend. He has devised instruments for humanity about 800 years ago, but unfortunately, his workings could not be unveiled until recently. In short, he may be considered as the flavor of cybernetics, robotics and automation of mechanical devices. He has expressed his ideas, opinions and views not in a subjective manner as many ancient Greek philosophers have done, but on objective grounds with drawings that can be convinced by everybody even today. Perhaps, his engineering side is more significant than his philosophical and scientific sides.

Following the first entrance of Turks into Asia Minor in 1071 with their leader Alpaslan Ghazi, one of the branches went towards the southern Anatolia. This branch is labeled as the Arthuque Turks and they are settled around the present-day Diyarbakir city and surroundings with the establishment of a small state there. Abou-l Iz Al-Jazari is one of the scholars who were trained in this state, and finally, statement's attention was drawn by this administration. He was supported by the then ruler for his robotic devices and the ruler asked him to collect all the devices in the form of a book with picturesque illustrations. He has done so and applied his ingenious devices in front of the people with gaining their appreciation. His full name is Badi'uuzzaman Abou-l İz bin Ar-Razzaz El-Cezeri. Badi'uzzaman means "the genius of the century". Even looking through his hand drawn mechanical devices in his book and their comparison with present day robotics will give in the first glimpse that he has designed machines that worked with water power and they are comparable with the present-day drawings. It is stated that his drawings gave rise to servo-mechanical thoughts, and consequently, cybernetics which as a branch of science emerged in recent years. His thoughts and drawings gave intuitional feelings towards mechanization in the 19th Century. The founder of history of science, Sarton (1950) mentioned about him as the son of rice merchant which is derived from the Arabic meaning of Ar-Razzaz. Al-Jazari means in Arabic that he belongs to the peninsula which implies the part of land between Euphrates and Tigris rivers because he lived in Diyarbakir in the southeastern part of today's Turkey. Basic information about him is obtained from the introduction section of his book titled "Kitab fi ma'rifat al-hiyal al-handasiyya". Accordingly, the ruler of Arthuque dynasty of Turks in the Diyarbakir region, Nasr'uddin period including his father and son reigns, Al-Jazari served this family for 25 years with his original ideas and automatic devices. He has implemented all the experience and experimental works in his original designs of mechanical devices although calculations were not available at that time. He has used numbers to describe certain quantities, but various parts of his devices were obtained in proportionate harmony with other elements of the device after a long and wearying trials and

errors. However, in the works of Muslim engineers, the remnants from Hellenistic period in the eastern Mediterranean have been efficient.

During the reign of Abbasid in Baghdad, vicegerents urged the translation of information, knowledge, philosophical and engineering books into Arabic and they have even established a house of wisdom titled "Bayt'ul-Hikmah" for this purpose. The purpose was to provide to Muslim scholars the previous works of different civilizations so that the society could prosper and become wealthy. Among these translations were the works of Philon of Byzantine period that lived during the second century after Christ and wrote a manual titled *Phenomatics* in addition to the work of Heron of Alexandria who existed in years 60s after the Christ. These two men had some work on the automatic objects but did not leave detailed documentation and theirs were the fragmentary remnants even without clear interrelationships between the pieces. There were not drawings either. During the translation period even, the works of Archimedes were translated into Arabic and these were mentioned in the work of Al-Jazari especially in the cases of water clocks. Al-Jazari's new the works of Archimedes, Philon, Heron and Muslim researchers Banu Musa (Moses Brothers) and he benefited from their enlightenments. It is possible to assess that Muslims began to work with automatically functioning mechanical devices with the works of Banu Musa from about 850 until 1206 when Al-Jazari died. During this period, Muslims reached the most fruitful designs and produced useful devices (Şen, 2013).

Until the time of Al-Jazari, another source of information about the mechanical devices came from the sayings and spread of information between people and both Banu Musa and especially Al-Jazari evaluated these sources of information also in their productive works. It can be said that these information together with Al-Jazari's original ideas and his literature review were collected in his famous book for the exploitation of future generations. Unfortunately, after his death his work has not been recognized for almost 5 centuries. His book is full of water power trusted mechanical devices. Al-Jazari has used measuring systems which were not in conform with today's system, but he carefully designed the pieces of the device so as they were in good harmony with the overall functioning. He has used even plane geometrical figurations in his design. On the other hand, the book *Mafatih Al-Ulum* (Keys of Sciences) by Khwarizmi in 991 has provided all the then available terminologies used in science and many researchers benefited from this work. In this book, there were even the pieces of *Hiyal* mechanical terminology in addition to their epistemological meanings. It provided a common place for Muslim engineers to use the same terminology especially at the end of the 10. Century Almost 200 years later, Ridwan Bin Al-Sa'ati has provided useful knowledges concerning the repairs and mechanical works of broken clocks in 1203. On the other hand, many Muslim researchers in the natural philosophy mentioned about some mechanical devices which also helped further developments. Even today their identification and collection in a separate work requires long and tedious study. Among the Muslim famous scholars are Biruni, Al-Hazini, Ibn-i Hatham, Caber Bin Hayyan, etc.

During the medieval period many authors in the west have agreed that Muslims were advanced in the modern scientific subjects such as the logic, philosophy, mathematics, optics, algebra, chemistry, medicine and astronomy. Unfortunately, so far the technological developments within this period by Muslim scholars have not been given the rightful emphasis. In fact, technological developments have pursued rather independent path from the philosophical thoughts and sought practical services to the societal activities. Among these were the windmills, waterwheels, sailboats, powder and fireworks, etc. During the medieval Islamic period, the best of the technological developments was gathered in a book by Ibn Al-Razzar Al-Jazari, "Kitab fi ma'rifat al-hiyal al-handasiyya" which was translated by Hill (1974) as "The Book of Knowledge of Ingenious Mechanical Devices". Hill stressed that of all the fields in which Muslims have made significant contributions to the progress of civilization that of mechanical technology has been the least studied. Technology has flourished whenever and wherever conditions have been favorable for its development and growth. Especially, technology has relatively fettered by ideologies, and therefore, found its way as a diffusion of ideas in different aspects of the practical life. So far in the history, technological developments have not been following a steadily increasing trend of knowledge but sudden jumps irrespective of geographical and political separations. Technological knowledge has been transferred to future generations through writings and in very rare cases through drawings. Al-Jazari's work is exceptional in this case, because his book does not only include detailed drawings but also the explanation of the devices' working mechanisms. Especially, when considered that many did not care to commit their devices to paper, Al-Jazari's work has invaluable place in the history of human technological developments. Mechanical arts have been flourishing in the Islamic world between the ninth and thirteenth centuries. This may be due to accumulation of verbal information transmission from the previous civilizations of the Middle and near East. Among these civilizations ancient Egyptians, Greeks, Romans and Byzantines have done in various ways small scale technological advancements. In the mean time, technological information from Persian, Indian and Far Eastern countries have entered the development, but Islamic technology was based mainly on the eastern Mediterranean civilization ideas. However, Muslims did not imitate the technological devices of the past, except if they were in use, but they developed original devices which were the product of Muslim scholars such as Al-Jazari. The driving forces behind the Islamic technological

development were twofold. On the one hand, the daily practical necessities were met by everyday use, such as water and windmills, especially water-rising devices, and war machines and on the other hand, devices that raised wonder and aesthetic pleasure between the people. Even at this junction, there were written documents for pleasure devices but very rare documents for everyday use devices. It is a fact that Al-Jazari did not hide any of his technological findings from others. He showed by constructing and functioning them in front of the people and more importantly by writing and drawing those in a book form.

Prior to Al-Jazari, in about 850, three sons of Musa bin Shakir who were known as Banu Musa in the Islamic literature, wrote a mechanical work which consisted of rich vessels, fountains, self-trimming lamps, music automata and others which were mostly on the pleasure side of the technology. Water clocks were also common among Muslims and they worked with water power mechanically. There were here and there written documents which were not written in a systematic manner and they were distributed in many different places. However, Al-Jazari's book composed of all the available then modern technological developments with mentioning about Aristotle in the opening of his book, but detailed information concerning each devise was also included in the book. Hence, Islamic technology is in great debt to Al-Jazari for collecting the most developed technological advancements of which mostly designed by himself in a systematic book. He included wide range and variety of devices, incorporating all the techniques and components used by his predecessors, as well as many of his original additions and improvements. He himself was a master craftsman and therefore, he was able to explain the details of each device and how it was constructed. All the authors from the Hellenistic, Roman or Islamic period gave the machines in a vague and imprecise manner without details and consequently, their functioning could not be properly understood by the successors. In the ninth century, an interest of machine use has risen between the Muslims and consequently, they have started to translate previous civilization contributions on this line during the Abbasid period when the Wisdom House "Bayt-ul Hikmah" was established. Several Greek treaties notably the *Pneumatics* of Philo of Byzantium and the *Mechanics* of Hero of Alexandria were translated into Arabic. Al-Jazari also acknowledged Archimedes in his book so far as the water clocks are concerned.

6.2 Automata (hiyal)

Automata are the immediate ancestors of the elaborate water clocks of Europe and they worked with water power mechanically. Some historians of technology have expressed discontent because so much of the ingenuity of the Muslim engineers was directed to the design and construction of such apparently trivial devices as automata, rather than to the making of useful machines. This view is quite erroneous, however, not only because it neglects the existence of a utilitarian tradition that was not recorded in writing, but also because it fails to consider the contribution made by the makers of *hiyal* to the advance of machine technology (Hill, 1974). The making of automata in ancient Greece, in Islam, and later in Europe was one of the factors that led men to develop rationalistic and mechanistic explanations of natural phenomena, an attitude that has been immensely fruitful in the development of modern science. It was Al-Jazari's monumental clock, however, that displayed the most impressive arrays of automata. The automata were actuated by a float sinking at a constant rate in a water reservoir. A string attached to the top of float passed around a large pulley wheel that was the main drive of the clock. Through other pulleys it rotated the zodiac circle and drew along, behind the face of the clock, small wheeled vehicle to which was fixed a vertical rod that operated the tripping mechanism. The success of water clocks is dependent directly on the achievement of a constant rate of water discharge. Al-Jazari located a vertical, conical valve seat at the end of outlet tap from the reservoir. Beneath this valve seat was a small float chamber, with the conical valve plug fixed to the top of the float. The outlet pipe was soldered to the lower end of the float chamber. When the top was opened, water ran into the float chamber and the valve closed monmentarily, only to reopen momentarily when water was discharged from the float chamber. The cycle repeated itself until the water in the reservoir was exhausted (Şen, 2013).

7. CONCLUSIONS

Technology has evolved rather independently from the philosophical thoughts and scientific theorems especially during the early civilizations. Humans urged shelter, protection from wild animals and weather conditions in addition to food for their survival and hence, tried to take care of themselves against natural phenomena in a safe manner. Different civilizations including China, India, Mesopotamia, Egypt, ancient Greek, Islam and the West have participated to the evolution of technologies throughout the history. Primitive technological developments in the roots of the historical origins of men can be identified through the single body of information that lies in the vast body of excavation reports prepared by numerous archeologists. The technological developments of larger scales have been elaborated by successive civilizations and there are written documents. Most of these documents have not been well identified especially in the Islamic civilization which shed flood lights on the classical Greek civilization with introduction to the Western renaissance in many aspects (Şen, 2013).

Abu-l Iz Al-Jazari who has lived during the 12th century is the father of robotics that worked by water power hydraulically. He has reviewed previous technology developers such as Vitruvius and Heron who have lived during the

first few centuries after the Christ in the Roman domain. Unfortunately, they have not left proper designs or procedures for the few technological ideas of their origin, but Abou-l Iz Al-Jazari has drawn many mechanically proper designs in his hand-written book which is printed in its original form by the Cultural Ministry of Turkey in 1990. It is the main purpose of this paper to mention the development of technological devices prior to Abou-l Iz Al-Jazari and then his original contributions are presented in the forms of several mechanically working devices that are used for water haulages and depend on water power. It is noticed that he is the first technology man who designed piston, cylinder, valves and different types of axles that contributed collectively to present day technology.

REFERENCES

Al-Hassan, A.Y., 1977. A compendium on the theory and practice of the mechanical arts. Madjattah al-Tarihi-l Ulum al-Arabiyya, Halep, 47-64.

Cultural Ministry of Turkey, 1990. Olaganüstü Mekanik Araçların Bilgisi Hakkında Kitap, (The Book of Knowledge of Ingenious Mechanical Devices), 355 pp.

Hauser, F., 1922. Über des Kitâb al Hiyal. In Abhandlungen zur Geschichte der

Naturwissenschaften und der Medizin, 89-99.

Hill, D., 1974. The Book of Knowledge if Ingenious Mechanical Devices. D. Reidel

Publishing Company, Dordrecht-Holland/Boston-USA

Hodges, H., 1970. Technology in the Ancient World. A Pelican Book, 260 pp.

Huff, T.E., 1993. The rise of early modern science, Islam, China and the West. Cambridge University Press, 409 pp.

Kuhn, S.T., 2000. Bilimsel Devrimlerin Yapısı (5. baskı). (Çev. Nilüfer Kuyaş), İstanbul: Alan Yayınevi.

Nasr, S. H., 1964. Three Muslim sages. Cambridge, Mass.,

Needham, J., 1954. Science and Civilization in China. 7 Vols., New York, Cambridge Press.

Sarton, G., 1950. Introduction to the History of Science. Robert E. Krieger Publishing Company, Malabar, Florida 2155 pp.

Şen, Z., 2000. Robot ve otomasyon biliminin öncüsü Abou-l Iz Al-Jazari, (Robotic and Automation science pioneer Abou-l Iz Al-Jazari) Osmanlı Su Medeniyeti Sempozyumu, Feshane, İstanbul, (in Turkish).

Şen, Z. (2013). Ancient water robotics and Abou-l IzAl-Jazari. Water Science & Technology Water Supply 13(1), 699-709.

Weber, M., 1951. The religion of China.Translated byHans Gerth. New York: Free Press.

Wiedemann, E., and Hauser, F., 1915. Über die Uhren in Bereich der Islamischen Kultur. in Nova Acto Academiae Caesarae Leopoldino – Caralinea, 100, 167-272.

Nasr, S. H., 1998. The Islamic Worldview and Modern Science. Selected Papers on Science and Islam. Vol. II. O.I.C. Committee on Science and Technology. Pages 45-63.