The Social Sciences 7 (3): 369-377, 2012
ISSN: 1818-5800


# Indigenization of Science in the Islamic Civilization

Roziah Sidik Mat Sidek and Mohd. Jailani Abdullah
Department of Arabic Studies and Islamic Civilization, Faculty of Islamic Studies,
Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor, Malaysia

**Abstract:** This study is an attempt to explain indigenization of science in the Islamic civilization. Indigenization of science refers to the transfer process of contemporary science from a different culture to another state or nation and simultaneously redigging the old science heritage of the other nation or nations nearest to the transferee state or nation. This process as claimed by Mohamad Zain had occurred in the Islamic civilization. Hence, this study analyses the situation which had occurred in the Islamic civilization in order to confirm or refute Mohamad Zain's claim. The importance of this study is relevant as many world civilizations including the European and Japanese civilizations had achieved excellence through the indigenization of science process. The methodology used is qualitative study through instrument analysis by way of textual and contextual study of prime sources. As a result, we find that indigenization of science did indeed take place in the Islamic civilization beginning with the translation of scientific works. The Islamic civilization had also carried out re-digging of old scientific heritage from earlier civilizations. This study also shows that the Islamic civilization was able to produce original scientific works written in Arabic language. This was the pinnacle of indigenization of science in the Islamic civilization.

**Key words:** Indigenization of science, Islamic civilization, Islamic heritage, scientific works, old scientific heritage, Malaysia

## INTRODUCTION

According to Mohamad Zain (2004), indigenization of science refers to a transfer process of contemporary science from a different culture to another state or nation and simultaneously re-digging of the old scientific treasure of the said nation or nations nearest to the transferee state or nation. This definition can be broken down into several elements which should happen in the indigenization process. It refers to the transfer of contemporary science from a different culture to another state or nation as one of the said elements. In almost all world civilizations, the transfer process of contemporary science from a different culture to another nation is closely linked to the translation of great scientific works into the national language of the latter. If the transfer of science involved transfer from the Hellesnitic-Greek civilization to the Islamic civilization then works written in Greek were translated into Arabic language. And if transfer of science involved transfer from the Islamic civilization to the Western civilization then the Arabic works were translated into English, Latin or German language depending on the national language of the nation in Europe. This translation is seen as evidence of the importance of a national language in developing the science of a nation. Thus, usage of a national language is one of the matters encompassed in the definition of indigenization of science.

Another aspect of indigenization of science involves the process of re-digging old scientific heritage. If the Islamic civilization is to be a model then this process needs to be seen as a process whereby scholars were intensely active to develop the said civilization by taking the initiative to re-dig their old scientific heritage or from civilizations nearest to them. We may not identify the said scholars as Muslim scholars because historical records show that many of those involved were not Muslim by faith. Among the activities of these scholars was to study scientific works from other civilizations. Such studies need to be viewed as an approach to gain a picture of the form of a particular knowledge from a civilizational perspective as well as its niche basis. At the same time, it was necessary as a mode to check the compatibility of its core knowledge to Islamic thinking. If it was found to be incompatible with Islamic thinking then revision of the core knowledge needed to be done. If a theory or idea cast in was doubtful then the scholars who were intensely active in building up Islamic science would give their commentary. Eventually, the scholars were able to produce their own original works which were fully

**Corresponding Author:** Roziah Sidik Mat Sidek, Department of Arabic Studies and Islamic Civilization, Faculty of Islamic Studies, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor

compatible physically, culturally and ideologically with the Islamic civilization. With this explanation, researchers should not face any difficulty to admit that indigenization of science is an important criterion to develop the science of any nation, not only of an Islamic civilization but also of the Malay civilization and civilization of every European nation as well as of Japan (Zain, 1998). However in the context of this study, researchers only touch on the indigenization of science in the Islamic civilization and not in other civilizations. This study aims to obtain evidence to confirm or refute Shaharir's claim that indigenization did occur in the Islamic civilization.

## THE STATUS OF INDIGENIZATION OF SCIENCE IN THE ISLAMIC CIVILIZATION

Researchers begin with a hypothesis that indigenization of science did indeed take place in the Islamic civilization. Beginning from the transfer of scientific knowledge from earlier civilizations through the method of translation of great scientific works, followed by the re-digging of old scientific heritage from nearby nations and advancing with the production of original works in the native language, the Islamic civilization thus later reached its golden age of excellence. The usage of Arabic language as the sole language in all fields throughout the whole of the Islamic world complemented indigenization of science in the Islamic civilization.

## THE TRANSFER OF SCIENCE FROM EARLIER CIVILIZATIONS

If researchers browse through the historical development of the Islamic civilization, we have to concur with the reality that the Islamic civilization did indeed transfer science from earlier civilizations such as Hellenistic-Greece, Persia, India and even China. This transfer covered many fields of knowledge such as philosophy, medicine, astronomy, chemistry and mathematics which were written either in Greek, Sanskrit, Pahlavi, Syriac or even Persian. In this case, Nasr (1976) described the transfer process as the most extraordinary model of culture transfer in the history of mankind. The transfer is believed to have occurred through the process of translation of scientific works from a foreign language into Arabic. This was because the Islamic world then was inhabited by society which used only the Arabic language. It was the sole language used in the whole of the Islamic world then whether in Baghdad or Cordova. Arabic language was not only used in daily speech but also in all fields including science and the arts. Al-Hassan and Hill (1986) have described this situation as a miracle for the Islamic civilization in that everyone who lived between Baghdad and Cordova used only a single language that is Arabic. On realizing the reality that the Islamic civilization could only benefit from knowledge transfer from other civilizations only if each member of society had access to information in his own language, an initiative was thus taken to translate such knowledge into Arabic.

## TRANSLATION OF SCIENTIFIC WORKS FROM EARLIER CIVILIZATIONS INTO ARABIC LANGUAGE

The activity of translating works from earlier civilizations into Arabic had already begun since Ummayad rule. However, this activity reached its peak during the Abbasid rule. According to Young *et al.* (1990), the translation movement of the Abbasid era lasted for about 300 years and it came to an end in the middle of the 5th century H/11th century AD. Iqbal (2007) similarly states that the said movement lasted for about three centuries. However at first impression, the statement by Nasr (1976) regarding the duration of the translation movement of the Abbasid era seems to be quite at variance that is 150 years. It began from the 2nd century H/8th century AD and lasted until the 4th century H/10th century AD. Nasr's statement seems to slightly contradict those of Young and also Iqbal's. However, what Nasr really meant is the time period within which translation of the majoriy of important works of earlier civilizations such as research of Hippocrates, Aristotle, Theophratus, Euclid, Ptolemy, Dioscorides, Galen and others were finalized. These translation efforts were not trivial tasks. Moreover, the works translated were great scientific works by renowned figures such as Hippocrates, Aristotle, Theophrastus, Euclid, Ptolemy, Dioscorides, Galen and many others as well as the usage of a target language that is Arabic which is precise and clear (Nasr, 1976). Nasr (1976) and Sarton (1975) are among the authoritative references who give information on translation of works from other civilizations into Arabic. There were various scientific and philosophical works from the Greek, Persian and Indian civilizations which were translated into Arabic during the golden age of the Islamic civilization.

Amongst the Hellenistic-Greek works translated into Arabic was the astronomical work by Ptolemy that is Megale Syntaxis Mathematike. On translation, it became known as Kitab al-Majisti. Ptolemy's astrological work that is Tetrabiblos or Quadripartitum was translated by Abu Yahya (Yuhanna) al-Batriq (d. 200H/815AD) during the rule of Khalifah al-Mansur with the title Kitab al-Arba$^{c}$

Maqalat fi Sinaᶜah Ahkam al-Nujum. Meanwhile, Ptolemy's work on Geography, Geographike Syntaxis was translated by Thabit ibn Qurrah with the title Kitab Jughrafiyya fi al-Maᶜmur wa Sifah al-Ard. The work by Dioscorides on pharmacology that is De Materia Medica was translated by Istafan ibn Basil (lived in the 3rd century H/9th century AD) during the reign of Khalifah al-Mutawakkil using the title Kitab al-Hasha'ish fi Hayula al-Tib (Sarton, 1975).

Galen's research which became the basis of medical curriculum and were known as Summaria Alexandrinorum were also translated. This translation effort was done by Hunayn ibn Ishaq. Among the said works were De Sectis Ad Eos Qui Introducuntur which was translated by the title Kitab al-Firaq, Ars Medica translated as Kitab al-Sinaᶜah, Ad Glauconem de Methodo Medendi translated with the title Kitab ila Aghluqan fi al-Ta'ti li Shifa' al-Amrad, De Temperamentis translated by the title Kitab al-Mizaj, Naturalibus Facultatibus translated as Kitab al-Quwa al-Tabi ᶜiyyah, De Morborum Causis et Symptomatibus Libri Sex translated as Kitab al-Ilal wa al-A ᶜRad, De Diebus Decretoriis translated as Kitab Ayyam al-Buhran, De Alimentorum Facultatibus translated with the title Kitab Quwa al-Aghdhiyyah, De Victu Attenuante translated with the title Kitab al-Tadbir al-Mulattif, etc. (Iskandar, 1976). Besides these, Hunayn ibn Ishaq also translated the medical works of Hippocrates (d. 257 BC), that is Aphorismos with the title Kitab al-Fusul (O'leary, 1964; Iskandar, 1976).

Other than Hunayn ibn Ishaq, Galen's works were also translated into Arabic by several individuals such as Hubaysh ibn al-Aᶜsam dan ᶜIsa ibn Yahya. Sarton (1975) reveals that Hubaysh ibn al-Aᶜsam had translated as many as 35 of Galen's works whereas ᶜIsa ibn Yahya had translated as many as 24 of his works. Amongst Galen's medical works translated by Hubaysh ibn al-Aᶜsam were De Locis Affectis by the title Kitab Taᶜarruf Ilal al-Aᶜda' al-Batinah, De Sanitate Tuenda with the title Kitab Tadbir al-Asihha', De Anatomicis Administrationibus with the title Kitab al-Tashrih al-Kabir, De Semine with the title Kitab al-Maniyy, De Usu Partium Corporis Humani with the title Kitab Manafiᶜ al-Aᶜda', De Bono Habitu by the title Kitab Khasb al-Badan, De Compositione Medicamentorum Per Genera by the title Kitab Tarkib al-Adwiyyah, etc.

And amongst Galen's medical works translated by ᶜIsa ibn Yahya were De Antidotis with the title Kitab al-Adwiyyah al-Muqabalah li al-Adwa', Prognosticum with the title Kitab Taqdimah al-Maᶜrifah, De Parvae Pilae Exercitio with the title Kitab al-Riyadah bial-Kurrah al-Saghirah (Iskandar, 1976), etc. Galen's medical works were also translated into Arabic by others such as De Motu Thoracis Et Pulmonis translated by Istafan ibn Basil with the title Kitab Harakat al-Sadr wa al-Ri'ah, De Probis Pravisque Alimentorum Succis translated by Thabit ibn Qurrah by the title Kitab al-Kimus and De Simplicium Medicamentorum Temperamentis Et Facultatibus translated by Yusuf al-Khuri (lived during the rule of Khalifah al-Muqtafi) with the title Kitab al-Adwiyyah al-Mufradah.

Works from the Indian civilization were also not spared from being translated into Arabic. Such works covered various fields including Astronomy, Mathematics and Medicine. The work on Astronomy and Mathematics entitled Brahmasphutasiddhanta was translated into Arabic with the title al-Sind Hind (Ronan, 1983). Translation was done by Abu ᶜAbd Allah Muhammad ibn Ibrahim al-Fazari at the command of Khalifah al-Mansur. According to Sarton (1975), this work became the main gateway in the direction of transferring the Hindu numerals system into the Islamic civilization. Other than that, Muhammad ibn Ibrahim al-Fazari and Yᶜaqub ibn Tariq also translated another Hindu astronomical work, that is, Khandakhadyaka with the title al-Arkand (Sharma, 2004).

Amongst the translated Indian medical works was that written by Chanakya (named as Shanaq in Arabic). According to Needham (1980), this writing of Chanakya was based on the original work entitled Arthasastra. Information Levey (1973) reveals that the work of this Indian medical man had been translated by Mankah from Persian into Indian language. Later it was translated by Abu Hatim al-Balkhi from Persian into Arabic language for Yahya ibn Khalid with the title Kitab al-Sumum wa al-Tiryaq. Another Indian work, Caraka Samhita by Charaka was translated by ᶜAbd Allah ibn Ali in the 3rd century H/ 9th century AD from Persian into Arabic with the title Sharik al-Hindi. And the work by Susruta (former Hindu surgeon of the 6th century BC) that is Susruta Samhita was translated into Arabic by Mankah with the title Kitab Susrud.

And from the Persian civilization, the work translated into Arabic was Kalilag u Dimnag (written in Pahlavi). This work contained a collection of Persian mythical stories. It was translated by ᶜAbd Allah ibn al-Muqaffa ᶜ and ᶜAbd Allah Ahwazi with the title Kalilah wa Dimnah. In addition to the said work, Ibn al-Muqaffaᶜ also translated other works such as Khudhay Namag (work on the biographies of Persian kings) with the title Siyar Muluk al-ᶜAjam (Sarton, 1975), Ayin Namag with the title Kitab Ayin Namah, Mazdak Namag with the title Kitab Mazdak, etc. (Ashtiany *et al*., 1990). Kitab Ayin Namah as explained by Hassan Azhari (2006) discusses Persian ethics, customs and traditions as well as laws. The Kitab

Mazdak relates stories of Persian religious leaders. In view of the tremendous efforts in translation into Arabic, Muslims today should be able to take pride in the existence of almost a quarter million manuscripts, most of them in Arabic. These manuscripts can be found in various libraries all over the world (Al-Hassan and Hill, 1986). The results of this translation could be easily accessed by every level of society in the Islamic civilization to obtain science information from earlier civilizations. This was possible because all the said information could be obtained in the society's own language that is Arabic language. This translation effort also needs to be viewed as a bridge for the Islamic civilization to know in detail the progress of science belonging to earlier civilizations.

In tne early phase of translation, scholars representing the Islamic civilization had merely translated without inserting any of their commentary on the knowledge in question. However, the situation changed in the 9th and 10th centuries AD when the translators began to insert their commentaries. According to Hairudin, the commentaries covered a critical analysis by the translator and archive notes as well as the history and geography of the translated material. In fact, there were instances where the translator shared his ideas or gave reasons for concurring with the ideas cast in by the writer or otherwise. This style of translation can be seen in Thabit bin Qurrah's translation of Appolonius's mathematical work entitled Conica and of Niccomachus's mathematical work entitled Introductionis de arithmeticae.

## DIGGING OF OLD SCIENTIFIC HERITAGE

Even though, the Islamic civilization translated scientific works of other civilizations into Arabic, it did not mean mere acceptance or even plagiarism. This is because those scientific works were full of different cultures, values and ideologies of other civilizations dissimilar to Islamic thinking. Hence, it is not surprising that scholars of the Islamic civilization were not merely dissatisfied with the result of translation but on the contrary, took the iniative to dig and explore the said knowledge heritage. This exploration made possible the integration of knowledge. Taking Mathematics as an example, exploration of the old knowledge heritage witnessed the integration of knowledge from a few civilizations such as Grecian Mathematics with Hindi Mathematics (Harun, 1992). Exploration of the old scientific heritage also saw the existence of new ideas thrown in by scholars representing the Islamic civilization. Analysis of this matter will be dealt with according to civilization beginning with the Hellenistic-Greek followed by the Indian and Persian civilizations.

**Re-digging of old scientific heritage from the Hellenistic-Greek civilization:** Scholars of the Islamic civilization had conducted much re-digging of old scientific heritage from the Helleenistic-Greece civilization. It was intensively carried out by prominent scholars of comparable caliber whether amongst translators themselves or amongst the scientists. The re-digging was also not restricted to only one field. In fact, it encompassed various fields such as Mathematics, Astronomy, Medicine, Geography, Botany, Minerology, etc. However in this study, researchers only focus only on a few fields that is Mathematics, Geography and also Mechanical Engineering.

In the field of Mathematics, for example, amongst the Grecian works which were re-dug were Megale Syntaxis Mathemathike produced by Ptolemy, Elements written by Euclid, De Sphaera Et Cylindro produced by Archimedes, Conica by Appolonios and others. Even though there are many Grecian works on mathematics which were re-dug, we are only focusing discussion on two works by Euclid dan by Appolonios. Euclid's work entitled Elements was re-dug by the prominent figure that is al-Khawarizmi. Through this process of re-digging, al-Khawarizmi found that Euclid's mathematical concept was based on numbers and deductive method. The said discovery had sparked an inspiration in him to introduce a new mathematical concept not tied to numbers only that is algebra.

The said concept is stated in detail in his famous work, namely, Kitab al-Jabr wa al-Muqabalah. al-Jabr, refers to the variation of a quantity from one side of an equation to the other whilst al-Muqabalah means to simplify a resulting expression (by eliminating the same term on both sides of the equation). The function of this new concept is to resolve problems of quadratic and linear equations by using a systematic and logical approach. This work was produced by al-Khawarizmi at the request of Khalifah al-Ma'mun, following the need for a simple method to be applied in resolving several problems of daily affairs such sale and purchase, land area measurement, calculation in property distribution of inheritance and wills. It was written in or about the year 209H/825AD.

The said book contains chapters which cover topics such as calculation in operations of multiplication, addition, subtraction and division; equations, measurement work; problems of sale and purchase; currency divisions; weights and measures; measurement of even plane; area of circle and triangle, volume of pyramid and cone; wills and distribution of inheritance estate. Through this work, al-Khawarizmi had achieved a new branch of knowledge never before invented by mathematicians before him. He had also introduced new terms still in use today which are variable (x), square of

variable ($x^2$) and constant (c). Recognition of his work is not only given by scholars in South-East Asia which have received Islamic influence but also by Western scholars, specifically in Europe. Zain and Samian (1987) who represent Mathematics scholars in South-East Asia for example, assert that al-Khawarizmi's work on algebra cannot be considered as a small discovery because without it, the set theory, advanced geometry, calculus and others would not have been discovered and developed with ease. The recognition of his great work by European scholars of the Middle ages was evident in their toil to translate it into Latin. Its Latin translation by Robert of Chester, for example had become an important basis in the development of Mathematics amongst other European scholars such as Leonard of Pisa, Cardan, Tartaglia, Luca Picioli, Ferrari and others. In fact, study and investigation by the said European scholars had further developed algebra to a more advanced level.

Apart from the work by Euclid, the work of Appolonius was also re-dug by scholars of the Islamic civilization. This effort was undertaken by the family of Banu Musa jointly with Thabit ibn Qurrah and Hilal ibn Hilal al-Himsi. Meri and Bacharach (2006) stated that the family of Banu Musa was very interested in the field of geometry. In the beginning, they were already in possession of maqalah 1-7 of Appolonios's work. However, the manuscript was difficult to understand because the handwriting was not legible. Thus they looked for other more legible manuscripts which could be easily understood and translated. Such a manuscript was finally found in Syria (accompanied by Eustocius's commentary) by Ahmad (Freid and Unguru, 2001). Banu Musa then hired Hilal al-Himsi to translate maqalah 1-4 whilst Thabit ibn Qurrah translated maqalah 5-7. In the process of re-digging, they found that Appolonius's work was very useful, specifically as a model to develop a new theory regarding cylinder and plane section (Montgomery, 2006). However, his work was undidactic as it did not explain to the reader theorems used as proof for each presumption. Thus, in an effort to improvement, Ahmad had added in the text of his translation of Appolonius's work, the theorems which Appolonius had used earlier to support his arguments (Hogendijk, 1992). In relation to this field, in the middle of the 3rd century H/9th century AD, Banu Musa had produced an original work entitled Kitab Maᶜrifah Misahat al-Ashkal. Based on the explanation of Rashed (1996) in the Encyclopaedia of the History of Arabic Science concerning Kitab Maᶜrifah Misahat al-Ashkal, it contains methods to calculate the circumscribed and inscribed areas of regular polygons. Likewise, it contains the method of finding the formula to calculate the area of a circle. According to them, the formula was obtained by the product of half of the diameter of a circle and half of the circumference. They proved that for each circle, the ratio of its diameter to its circumference is the same. The value of the said diameter ratio is $>3^{10/71}$ and $<3^{1/7}$. Besides this, they also explained the theorem used by Archimedes dan Heron to calculate the area of a triangle by using its sides.

Besides that Ptolemy's work entitled Geographia was also re-dug by scholars of the Islamic civilization. In the early stage, it was translated several times into Arabic language by translators of the Abbasid era including Thabit ibn Qurrah. This work contains several principles regarding the process of map-making such as the basic rules, methods of dividing areas, techniques of coordinate listing (longitude and latitude) and the main principles of preparing a map. Thus, Ayyubi gave his view that al-Khawarizmi had used the said work as a model for his original work, that is, Kitab Surat al-Ard (Book of the Image of the Earth). We believe that the writing of Kitab Surat al-Ard was the result of re-digging of the said work by Ptolemy. This is proven by the existence of several of Ptolemy's influence in his work. For example, among the four maps produced together with his work such as maps of the Island of Ceylon, the Java sea, the Azov Sea and the River Nile, the last two were in Ptolemy's work, Geographia (Bagrow and Skelton, 1985). Apart from this, according to Ayyubi, Ptolemy's influence can also be seen in his work from the aspect of dividing earth's surface area into seven (climate/ iqlim ) areas.

Kitab Surat al-Ard contained almost all the longitudes and latitudes for every area encompassing cities, mountains, rivers, islands and others based on their respective coordinates in a tabular schedule. It was also annexed to several maps including the first world map of the Islamic civilization in commemoration of Khalifah al-Ma'mun, that is, al-Surah al-Ma'muniyyah/Ma'munic map. This map was the result of al-Khawarizmi's work together with 70 other geographers, by order of Khalifah al-Ma'mun to draw a world map.

Unfortunately, the said map was lost. However, al-Masᶜudi (d. 344H/956 AD) managed to have a look at the said map. He considered it as the best map in comparison to Ptolemy's map and also Marinos's map (Bagrow and Skelton, 1985). We cannot ascertain from which aspect the al-Ma'mun map was said to be better than the other two maps. Perhaps what is portrayed by Harley and Woodward (1992) regarding the map may shed some light. They explained that the al-Ma'mun map was very clear and complete. It showed the earth as a sphere in a complete universe. It also contained pictures of the land, seas, inhabited and totally uninhabited areas, areas where human settlements focused, towns, cities, etc.

According to Ayyubi, al-Ma'mun map had been re-drawn based on the description and data contained in Kitab Surat al-Ard. This worthy task was undertaken by Dr. S. Razia Jafri that is one of the staff of the Aligarh Islamic University, India. The born again map together with an introduction written by Dr. Kamal Ayni and Prof. S. Maqbul Ahmad was printed and published by the Soviet Tajikistan Science Academy.

Scholars of the Islamic civilization also re-dug and explored old scientific heritage in the field of mechanical engineering. Nadarajan stated that re-digging of Philo's work entitled Pneumatica, Archimedes's Apropos (work on water clock) and Heron's Mechanica and Pneumatica had sparked the innovation and creativity of scholars of the Islamic civilization especially in the field of engineering. One of the scholars who had re-explored old scientific heritage was Banu Musa ibn Shakir (Ibn Shakir, 1979). The results of re-digging had attracted those in the field of engineering, especially pneumatic and aerostatic. Thus, Banu Musa ibn Shakir was able to produce his work entitled Kitab al-Hiyal (The Book of Ingenious Devices). Abdullah (2004) states that Kitab al-Hiyal was written in Baghdad in the year 235H/850AD. It discusses about 100 different devices such as jet light, gas mask, etc. It also contains theory and practical on aerostatics and hydrostatics as well as the use of automatic control and switch system.

**Re-digging of old scientific heritage from the Indian civilization:** The contribution of the Indian civilization in driving the scientific progress of the Islamic civilization was just as important. Amongst the scientific fields of the Indian civilization which had been re-dug are Astronomy, Mathematics and Medicine.

In the fields of Astronomy and Mathematics, an Indian civilization work entitled Brahmasputasiddhanta was re-dug several times. Muhammad ibn Ibrahim al-Fazari was the person responsible for the first re-digging after he was ordered by Khalifah Abu Ja$^{c}$afar al-Mansur to translate it into Arabic language. According to Nallinu during the re-digging, he had discovered methods of calculating planetary motion as well as several activities relating to astronomy. In consequence, he had produced a work entitled Zij al-Sindhind al-Kabir (Rashed, 1996). This work contains the Zij to observe the motion of celestial objects. This work became the prime reference of that time in aspects relating to astronomy. Brahmasputasiddhanta was next re-dug by al-Khawarizmi, at about the end of the 2nd century H/8th century AD. It occurred while he was writing an abstract concerning its contents by the order of Khalifah al-Ma'mun (Qasmi, 2006). The effect of the re-digging had a great impact on the development of Mathematics in the Abbasid era, especially in the field of Arithmetics. According to Smith, Brahmasputasiddhanta which was produced by Brahmagupta (d. 44H/665AD) had availed various useful information on the Indian knowledge relating to spheres, planets, arithmetics and several other branches of science. In consequence of the re-digging, the Hindi numerals and system of reckoning were discovered.

In the field of medicine, the Indian work entitled Caraka Samhita and Susruta Samhita were re-dug. Caraka Samhita was re-dug by $^{c}$Abd Allah ibn $^{c}$Ali in the 3rd century H/9th century AD. Susruta Samhita was re-dug by Levey (1973). The Arabic versions for these two works were Sharik al-Hind and Kitab Susrud. Both these Arabic versions were re-dug by $^{c}$Ali ibn Rabban al-Tabari. We would like to clarify here in detail regarding Susruta Samhita (Kitab Susrud) that is how re-digging of this work had been utilized by $^{c}$Ali ibn Rabban al-Tabari specifically to produce his own work Kitab Firdaws al-Hikmah.

We begin with the view of Levey (1973) which states that $^{c}$Ali ibn Rabban al-Tabari discussed food and medicine in his work Kitab Firdaws al-Hikmah which was quoted from Kitab Susrud. He mentioned that food enriches the life of man whilst medicine may change the human body system to a particular condition or state. Bitter medicine may eliminate thick phlegm in the throat, sour medicine may clear the duct while sweet medicine nourishes the organs. Levey's view is supported by more recent studies by Pormann and Smith (2007) who assert that Kitab Susrud had been an important source in the writing of Kitab Firdaws al-Hikmah.

**Re-digging of old scientific heritage from the Persian civilization:** In the process of re-digging old scientific heritage of earlier civilizations, scholars of the Islamic civilization also re-dug great Persian works. For example, Kalilag u Dimnag was re-dug by $^{c}$Abd Allah ibn al-Muqaffa$^{c}$ and $^{c}$Abd Allah Ahwazi. This work is actually a collection of Indian mythical stories contained in the work entitled Panchatantra/Pancatantra. It was written by an Indian intellectual named Pandit Vishnu Sharma around the year 200 BC. It was originally written in Sanskrit especially, for the King, Raja Dabschlim. It contained moral values which were uncovered through animal stories on the prerequisite qualities to be a good head of state. The leading animal characters in the stories were two wolves by the names of Karataka and Damnaka.

During the reign of Khusraw/Kisra 1, a renowned minister by the name of Burzoe/Barzawayh had translated this work from Sanskrit into Pahlavi language, entitled Kalilag u Dimnag. $^{c}$Abd Allah ibn al-Muqaffa$^{c}$ and $^{c}$Abd

Allah Ahwazi later translated it into Arabic language using the title Kalilah wa Dimnah (Letvinsky *et al*., 1996). This work later became the prime study resource on animals as well as for the moral message in the behaviour of animals who share life in this world as creatures of Allah (Nasr, 1976).

Persian scientific works in the field of astronomy such as Zij al-Shahriyar/Zij al-Shah/Zij Shahriyaran al-Shah (Royal Almanac) were also re-dug. In Pahlavi language Zij al-Shahriyar is pronounced as Zik-i Shatro-ayar. After translation into Arabic language by ʿAli ibn Ziyad al-Tamimi (known as Abu al-Hasan) in the 2nd century H/8th century AD, it became known as Zij al-Shahriyar/Zij al-Shah/Zij Shahriyaran al-Shah. Historically, Zij was compiled during the reign of Khusraw I Anushirvan (532-580AD) and re-edited during the rule of Yazdajir III (632-651AD) that is the last Persian ruler (Letvinsky *et al*., 1996).

Re-digging of this work involved several scholars such as Masha' Allah, al-Khawarizmi, Abu Maʿshar and al-Biruni. According to Holt *et al*. (1970), in the beginning of the 3rd century H/9th century AD, Masha' Allah (d. 199H/815AD) had used the Zij as the basis for calculation in the field of astronomy. And in the middle of the 3rd century H/9th century AD, al-Khawarizmi had made a report on the periodical planetary motion based on quotations from the Zij al-Shahriyar. Further, in the same century, Abu Maʿshar (d. 273H/886AD) had compiled an astronomical schedule with the Zij as a guide. We believe that al-Biruni too had re-dug the said Zij based on the similarities found in his work Rasa'il al-Biruni. This book contains four maqalah which discuss Mathematics and Astronomy. According to Kennedy (1956), al-Biruni had repeated in his book, a quotation from the said Zij on the calculation of the distance between Babylon and al-Qubba. Besides that he also repeated the method of determining time during the day based on shadows. Thus, this fact proves that the old scientific heritage of the Persian civilization too played a role in the development of scientific traditions in the Islamic civilization, specifically in Astronomy.

In the field of Medicine, re-digging was done by Abu Bakr Ahmad ibn ʿAli ibn al-Wahshiyyah al-Kaldani (3rd century H/9th century AD) on the work of Yarbuqa al-Nabati al-Kasdani al-Fuqai. Unfortunately, we could not trace the title of the said work. Re-digging of this work also shows that the Persian civilization also contributed to the development of medicine in the Islamic civilization, particularly with regard to knowledge on poisons. Extending from this re-digging, Ibn al-Wahshiyyah had produced a book entitled Kitab al-Sumum wa al-Tiryaq (Anees and Hamarneh, 1983). Levey (1973) is of the view that the writing of this book is the result of translation of Yarbuqa's work and also Suhab Sat on poisons by Ibn al-Wahshiyyah. Amongst the discoveries obtained by Ibn al-Wahshiyyah from re-digging of old scientific heritage were:

- Not all poisonous herbs are useless, in fact, sometimes, they can be used as substance for therapy treatment
- Poisons can be obtained from various sources such as plants, animals and even minerals

## THE MIRACLE OF ARABIC LANGUAGE

It is not difficult for us to accept the reality that the Islamic civilization realized the difficulty of building a civilization if science were to be studied through a language medium known to only an elite few. Because the Arabic language was the sole language used in the whole of the Islamic world then it was highly appropriate to ensure that scientific works existed in the same language. It was hoped that this situation would give full opportunity for every level of society to benefit from the said knowledge. This was the true miracle for the Islamic civilization which was able to uphold the status of the Arabic language as the spoken and written language of the society which lived between Baghdad and Cordova. Moreover, the Arabic language was used not only in the arts or sciences, but in all fields of knowledge.

The Islamic civilization at that time perhaps realized the experience of the Hellenistic-Greek civilization and made it as a guideline to develop its own civilization. In the Hellenistic-Greek civilization, the Greek language was used in the fields of arts and science particularly in Alexandria whereas the national languages were Aramaic and Coptic. This situation made it difficult for societies which did not understand Greek to obtain any scientific information. Thus indirectly, a wide boundary was built between the society and the scientific community. This situation made science as an exclusive field only for the Greek-speaking class. When the Islamic civilization took the initiative to translate great scientific works into Arabic language, it was seen as availing information in the said field in the language used by every level of society at once dismantling the cultural boundary and making science an open field for all and not exclusive to only a particular group.

Producing original works in Arabic language: Indigenization of science would reach its peak when a particular cicvilization succeeds in producing its own original works in its own language. In fact, the existence of original works would indicate the success of

indigenization of science. By taking only four fields as examples that is Chemistry, Astronomy, Medicine and Mathematics, specifically between the years 132-656H/750-1258AD, it is sufficient to show the intensity of the activity of producing original works in the Islamic civilization. We have succeeded in tracing at least 269 works relating to chemistry and medicine for that period and for the fields of Astronomy and Mathematics, we have identified at least 63 and 177 original works, respectively. In fact, the 177 original works for Mathematics can be further divided into sub-fields. About 76 of those original works represent Arithmetics, 29 for Algebra, 65 for Geometry and 7 for Trigonometry.

Amongst the works for Chemistry and Medicine is a voluminous encyclopeadia entitled al-Hawi by al-Razi, al-Qanun fi al-Tib by Ibn Sina, Kitab al-jadari wa al-hasbah by al-Razi, Kitab al-tasrif by al-Zahrawi, Risalah fi kimiya' al-'atr by al-Kindi, Tadhkirat al-kahhalin by Ali ibn 'Isa and Kitab al-'umdah fi sina'at al-jirahah by Ibn al-Quf. One of the original works in the field of Astronomy is Tadhkirah by Nasir al-Din al-Tusi. Other original works in the same field are Qanun al-Mas'udi by al-Biruni and Nihayat al-idrak by Qutb al-Din al-Shirazi. In the field of Mathematics, specifically Arithmetics, there are Kitab al-fakhri by al-Karaji, Miftah al-hisab dan al-Risalat al-muhitiyyah by Kashani and Talkhis a'mal al-hisab by al-Marrakushi. Works on Geometry comprise of Kitab ma'rifat misahat al-ashkal by Banu Musa and Fi ma yahtaj ilayhi al-sani' min al-mal al-hindisah by Abu al-Wafa' al-Buzjani. The existence of original works on Trigonometry can be seen in the appearance of works such as Almagest by Abu al-Wafa' al-Buzjani, Maqalid 'ilm al-hay'ah by al-Biruni and Kitab shikl al-qita' by Nasir al-Din al-Tusi. And works on algebra were comprised of Kitab al-mukhtasar fi hisab al-jabr wa al-muqabalah by al-Khwarizmi, Kitab al-fakhri by al-Karaji and Kashf al-asrar an ilm al-ghubar by Abu al-Hasan al-Basti (Nasr, 1976).

The existence of original works is proof that the Islamic civilization did not only depend on translations of scientific works from earlier civilizations to develop its science. On the contrary, those translations formed only the basis to obtain scientific information from earlier civilizations.

The information was developed through further study until scholars were finally able to take pride in their own original works which were more compatible physically, culturally and ideologically with Islamic thinking. Hence, it can be surmised here that the assertion or claim of Mohamad Zain (2004) that indigenization of science did actually take place in the Islamic civilization is valid.

## CONCLUSION

The transfer of science from earlier civilizations through the method of translation of scientific works into Arabic language and the digging of old scientific heritage from civilizations nearest as well as the producing of original works in Arabic are seen as firm proof that indigenization of science did actually take place in the Islamic civilization. The use of Arabic language as the sole language to develop science also contributed to the same end. Transfer of science had presented an opportunity for the Islamic civilization to gain access to scientific information from earlier civilizations. Whilst translation of scientific works into Arabic was seen as a way to avail easy passage for every level of society to gain access to the said scientific information. Thus, every level of society could contribute to scientific progress. Other than that the producing of original works in Arabic was seen as one way to develop a science which was compatible with the physique, culture and ideology of the said nation or civilization. With these facts, we need to affirm the reality that indigenization did indeed take place in the Islamic civilization. In fact, it had actually boosted the Islamic civilization to achieve excellence in the said fields.

## ACKNOWLEDGEMENTS

Research for this study was supported by a grant from National University of Malaysia Incentive Grants for Young Researchers (UKM-GGPM-CMNB-140-2010) and National University of Malaysia Incentive Funds for Young Researchers (UKM-DIPM-017-2011).

## REFERENCES

Abdullah, A.B., 2004. Introducing the Field of Engineering: Perceptions and Contributions of Islam. PTS Publication, Bentong, Malaysia.

Al-Hassan, A.Y. and D.R. Hill, 1986. Islamic Technology: An Illustrated History. Cambridge University Press, Cambridge, ISBN: 9789231022944, Pages: 304.

Anees, M.A. and S.K. Hamarneh, 1983. Health Science in Early Islam. 2nd Edn., Noor Health Foundation and Zahra Publication, Texas.

Ashtiany, J., T.M. Johnstone, J.D. Latham, R.B. Serjeant and G.R. Smith, 1990. Abbasid Belles-Lettres: The Cambridge History of Arabic Literature. 2nd Edn., Cambridge University Press, New York, USA., Pages: 517.

Bagrow, L. and R.A. Skelton, 1985. History of Cartography. 2nd Edn., Precedent Publications, Chicago, USA., Pages: 312.

Freid, M.N. and S. Unguru, 2001. Apollonius of Perga's Conica: Text, Context, Subtext. 222th Edn., Brill, Leiden, Holand, Pages: 499.

Harley, J.B. and D. Woodward, 1992. The History of Cartography: Cartography in the Traditional Islamic and South Asian Societies. 2nd Edn., The University of Chicago Press, USA., Pages: 579.

Harun, H., 1992. From Greek Science to the Science of Islam: Role and the Absorption of Foreign Science in the Formation of Classical Islamic Sciences. University Malaya Publisher, Kuala Lumpur, Malaysia.

Hassan Azhari, A.R., 2006. Faktor-faktor peminjaman bahasa asing ke dalam bahasa arab: Satu kajian linguistik sejarawi. Pertanika J. Soc. Sci. Hum., 14: 149-164.

Hogendijk, J.P., 1992. Transmission, transformation and originality: The relation of Arabic to Greek geometry. Proceeding of the Two Conferences on Pre-Modern Science, (PMS'92), Brill Publisher, pp: 20-20.

Holt, P.M., A.K.S. Lambton and L. Bernand, 1970. The Cambridge History of Islam. 1st Edn., Cambridge University Press, UK.

Ibn Shakir, B.M., 1979. The Book of Ingenious Devices. Reidel Publishing Company, Dodrecht, The Netherlands.

Iqbal, M., 2007. Science and Islam. Pentagon Press, New Delhi, India.

Iskandar, A.Z., 1976. An attempted reconstruction of the Late Alexandrian medical curriculum. J. Med. Hist., 20: 235-258.

Kennedy, E.S., 1956. A Survey of Islamic Astronomical Tables. 46th Edn., American Philosophical Society, Philadelphia, USA.

Letvinsky, B.A., Z. Guang-da and R.S. Samghabadi, 1996. History of Civilizations of Central Asia, The Crossroads of Civilizations: A.D. 250 to 750. UNESCO, Paris, ISBN: 978-9231032110, Pages: 569.

Levey, M., 1973. Early Arabic Pharmacology: An Introduction Based on Ancient and Medieval Sources. Brill Academic Publishers, Leiden, The Netherlands, ISBN: 978-9004037960, Pages: 195.

Meri, J.W. and J.L. Bacharach, 2006. Medieval Islamic Civilization: An Encyclopaedia, Routledge. Taylor and Francis Group, New York.

Mohamad Zain, S., 2004. Requirements, rules, status and agenda of indigenizaion of science in Malaysia: We are not going anywhere? In National Seminar of History and Philosophy and Science, pp: 1-24.

Montgomery, J.E., 2006. Arabic Theology, Arabic Philosophy: From the Many to the One: Essays in Celebration of Richard M. Frank. Peeters Publishers and Department of Oriental Studies, Louvain Belgium.

Nasr, S.H., 1976. Islamic Science: An illustrated Study. Westerham Press Ltd., Westerham, Kent, England, pp: 15.

Needham, J., 1980. Science and Civilisation in China. Cambridge University Press, UK., UK..

O'Leary, D.L., 1964. How Greek Science Passed to the Arabs. Routledge and Kegan Paul Ltd., London.

Pormann, P.E. and E.S. Smith, 2007. Medieval Islamic Medicine. Edinburgh University Press Ltd., Edinburgh, UK.,.

Qasmi, A.H., 2006. International Encyclopaedia of Islam. Isha Books Publishers, New Delhi.

Rashed, R., 1996. Encyclopaedia of the History of Arabic Science. Routledge and Kegan Paul Ltd., New York, ISBN: 978-0415020633, Pages: 1242.

Ronan, C.A., 1983. The Cambridge Illustrated History of the World's Science. Cambridge University Press, Cambridge, ISBN: 9780521258449, Pages: 543.

Sarton, G., 1975. Introduction to the History of Science: From Homer to Omar Khayyam. R. E. Krieger Publishing Company, Florida, USA., ISBN-13: 9780882751726.

Sharma, P.D., 2004. Hindu Astronomy. Global Vision Publishing House, Delhi, India. Pages: 294.

Young, M.J.L., J.D. Latham and R.B. Serjeant, 1990. The Cambridge History of Arabic Literature: Religion, Learning and Science in the Abbasid Period. 1st Edn., Cambridge University Press, New York, ISBN: 978-0521028875, Pages: 612.

Zain, M.S. and A.L. Samian, 1987. Islamization of Mathematical Sciences. In: Islam and the Current Thinking. Bakar, O. (Ed.). ISA. Malaysia (ASASI), Petaling Jaya, Malaysia..

Zain, M.S., 1998. Towards a quantum leap in the development of Islamic science in Malaysia. In: Islam: Science and technology. Ab Razak, A. and A.B. Abdul Majeed (Eds.). IIU. Malaysia, Kuala Lumpur, Malaysia.