Epistemology of Knowledge for Technical and Engineering Education

Rohana Hamzah\textsuperscript{a,*}, Sarimah Ismail\textsuperscript{b}, Kamarudzaman Md Isa\textsuperscript{c}

\textsuperscript{a}\textsuperscript{b}Faculty of Education, Universiti Teknologi Malaysia, UTM Skudai, 81310 Johor, Malaysia

\textsuperscript{c}Universiti Teknologi Mara, 40450 Shah Alam, Selangor, Malaysia

Abstract

There are three important components in engineering education which are knowledge, skill and attitude. Knowledge is defined as facts and concept of engineering education. The skills are those used by engineers in managing and applying their knowledge in solving problems. Whilst, attitude is how people use their skill and knowledge through personal values, concerns, preferences and biases toward their professional goal. The challenge of the century is to prepare a knowledgeable generation, particularly having the knowledge, skill and attitude beyond the range of traditional engineering curriculum. Thus, the focus of engineering education should shift from the simple presentation of knowledge to the concept of integration of knowledge. This requires a better understanding on the meaning of education. Hence, this article presents an attempt to crystallize the meaning of education, the concept of knowledge from philosophical perspective, and its relationship with human nature or fitrah. Based on the review, a conceptual model for epistemology of knowledge in engineering education is proposed.

© 2012 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of Centre of Engineering Education, Universiti Teknologi Malaysia Open access under CC BY-NC-ND license.

Keywords: Epistemology; knowledge; unity; integrated; fitrah

1. Introduction

Technical and engineering education is one of the disciplines focusing on acquiring and application of technical, scientific and mathematical knowledge to design and solve problems. According to Rugarcia, Felder and Woods (2000), the primary values of engineering education at the very beginning of education practice were for functionality and profit. Most of engineering education curriculums reinforced these values. However, the rapid change in knowledge, skill, technology and values has bought a real big challenge to the engineering
education system in preparing competence work force for tomorrow. The real big challenge of engineering education today is not only to produce expert in engineering disciplines, but also to produce knowledgeable students who are able to integrate and develop scientific knowledge in problem solving process.

There is also inappropriate assumption among those who designed the technical and engineering curricula for the past half-century. The technical and engineering curriculum designers think that by including several humanities courses or so call as academic subject such as moral, religious and history in engineering curriculum is sufficient enough to produce responsible and ethical engineers. The failure of the engineering curricula to address attitudes and values systematically has had regrettable consequences. According to Rugarcia, Felder and Woods (2000), most of the times engineers make decisions without feeling a need to take into account any of the social, ethical, and moral consequences of those decisions. They believed that those attitudes and values are someone else’s responsibility (Rugarcia, Felder and Woods, 2000).

Moreover, a critical problem in technical and engineering education nowadays is to produce independent learners. However, most of engineering students have a tendency to be dependent learners because all knowledge is known and obtainable from teachers and texts. The students’ tasks are to absorb what they are told and then demonstrate having done so and understand by repeating what they have learned from their teachers or lecturers (Rugarcia, Felder and Woods (2000). Therefore, every point of view is either right or wrong. The education process has influence the way they think. They tend to be dualist thinker because have been exposed to well planned problems solving process for the very specific career that they are trained. The situation is different when students enter the real world of work that involves the integration of various branches of knowledge in solving a problem. Therefore, they need to learn and relearn and understand other area of knowledge from what they have been trained. However, the education process has not really prepared them to face this challenge. In other words, current practice in education has shaped the students to become dualist thinkers who are not really be able to integrate various branches of knowledge in problem solving process in the real world setting.

According to Isharaf Hossain (2009), dualist thinker resulted from the dual education systems; the traditional Islamic education system and the modern secular education system. The root of this problem can be clarify by examine the history of engineering education curriculum development process. Since most Islamic countries were colonized by western countries, the secular education system has been adopted and implemented in those Islamic countries. Unfortunately, the adoption has developed confusion about the original vision of education and knowledge development process. The original vision of education is to produce a leader meanwhile, the process of education is to produce future workers to fullfill industries need in the future. As a result, the sublime and spiritual aspect of education has been ignored (Wahid Bakhsh Shaikh, 1999), but attention was given to the development of knowledge based on western philosophy that emphasizes on scientific evidence. Therefore, the adoption impact has created dualism phenomenon in epistemology of knowledge among scholars, thinkers and every aspect of human life (Syed Mohammad Dawilah al-Edrus, 2007).

Dualism in knowledge development process also produced well-informed students in a specific area of study but could not make association and integration between knowledge. As a result they are also very weak in decision making (Rohana, 2009). The long term impact of dualism in knowledge is the development of conflict and crisis in thinking process as well as in moral judgment when human being is not able to differentiate between the truth and the false, or between good and bad (Anuar Ahmad, 2009). The following sub-topics in this paper will discuss further about the concept of knowledge, unity through the diversity of knowledge and the concept of unity through epistemology of knowledge development in engineering education.
2. The Concept of Knowledge

According to an Islamic scholar, Al-Farabi, knowledge is defined as the cause of things especially when it deals with scientific knowledge. Meanwhile, the word science itself comes from the Latin “scientia” meaning knowledge (Anuar Ahmad, 2009). Omar Jah in Wan Mohd. Nor Wan Daud & Muhammad Zainiy Uthman (2010) views knowledge as a certainty that is contrary to doubt.

Meanwhile, Al-Ghazali defines knowledge as intellectual realities. The knowledge that sees things as it is. The thing is occasionally denoted as the known or object of knowledge or as an existent. The thing as ‘it really is’ is the reality of the thing, its essence, its universal meaning or its spirit. Knowledge also can be defined as a sense of permanence felt by anybody who is searching for the truth. Then, sense of permanence develops sense of certainty about the truth. Therefore, at least two elements play as a fundamental role in shaping knowledge. They are the factor of “permanence” which refer to the spiritual and universal meaning of the object of knowledge and the “principle of clarity”, which is concerned with the observation and perception of the observer (Mohd Zaidi, 2002).

According to Mohd Zaidi (2002), when something is considered in it, it is named existent. The truth (knowledge) only occurs when the “permanence” or the universal meaning be compatible to the physical existence. Therefore, the more permanence element inherent in an object, the more real it is and the truer the perception is. The perception becomes more real when the observers develop their certainty about the permanence element in the object. The significant impact of this process brings the observer closer to the Creator (God). Hence, the goal of developing intellectual knowledge based on observation on physical existence is to develop observers’ certainty about the permanence or universal meaning which is God as the only Creator.

Al-Ghazali had identified two purposes of acquiring knowledge which are; as a means to an end and as the end itself. In his further explanation, “it is in itself delightful and therefore required for its own intrinsic value”. The second objective of acquiring knowledge is as a way which leads to happiness, the only means whereby all creations come close to God (Mohd Zaidi, 2002).

There are three levels of knowledge; knowledge acquired through reasoning, knowledge arrived at by means of observation and true knowledge which corresponds to direct experience that is the intuitive knowledge or inspiration (Omar Jah in Wan Mohd. Nor Wan Daud & Muhammad Zainiy Uthman, 2010). Reason and experience alone as identified by modern scientists as the only sources of knowledge, cannot lead to true certainty or absolute reality. The true certainty in knowledge will lead to the recognition and acknowledgement of the proper place of God in the order of existence and the proper place of mankind in the order of all God’s creations.

Since technical and engineering education put a significant emphasis on the application of knowledge, it seems very important to discuss the meaning of application of knowledge. The application of knowledge means, putting things in their proper place in the order of creation (Omar Jah in Wan Mohd. Nor Wan Daud & Muhammad Zainiy Uthman, 2010). This represents justice and wisdom in human activities or as a natural outcome of freedom of choice. For that reason, the development of knowledge has direct impact on the way in which human beings relates to Allah as the absolute reality, to other human beings and to the physical environment and nature (Fazlur Rahman 1999). The development of scientific knowledge or intellectual knowledge which is based on observation by the ‘eyes and the ears’ is more significant if the knowledge finally is able to ‘strike the heart’, understand its relationship and responsibilities toward society and physical world and to kindle a perception in the human being which later transform its scientific and technological skills in accordance to God’s will. Only then engineering education system could produce engineers with high principle of moral standard values and who are be able to contribute for peace and harmony to this physical world.
3. Epistemology of Knowledge: Unity through the Diversity

Al-Ghazali defines the epistemology as a nature and a way of acquiring knowledge. In an epistemological process, it is the spirit of a thing, but not the thing itself that is apprehended (Mohd Zaidi, 2002). In order for knowledge to materialize, the meaning of knowledge holds it similarity in the cognitive form and the existential form. Al-Ghazali identified the soul (the permanence entity in God’s creation) as the actual set of knowledge. The source of knowledge in Islam is revelation. The revelation knowledge is communicated through holy book of Qur’an and the law of nature reveal by all God’s creation. Therefore, the method to obtain the knowledge must involve the integration of reasoning faculty (intellectual activity which involve observing God’s creation) and the fitrah or the internal senses of the human nature to be pure submission to God (spiritual dimension). Meanwhile, the result should be consistent with the human nature, the laws of the universe, Islamic teachings and values.

Meanwhile, according to Syed Naquib Al-Attas (2001), mankind consists of dual nature. Therefore, knowledge that purports to serve them best would be of dual aspect; the prior is that which serves his more permanent, spiritual dimension or the core knowledge; and the other his secondary, material and emotional mode of existence. Therefore, Syed Naquib Al-Attas and Al-Ghazali classified knowledge into two categories. The first category is fard ayn or religious science and the second is the fard kifayah or intellectual science which includes the physical, engineering and technical sciences.

The religious knowledge is the highest and it is related to mankind’s nature (fitrah) that Allah has given in every soul the knowledge that God as the only creator and we are servants to Him. The fitrah is the ‘pure state’ containing God’s consciousness so that every mankind can experience God’s perception of the world (Muhammad Al-Mahdi, 2005). This knowledge must be pursued from the age of responsibility until the death-bed and cannot be limited primarily to schooling. Therefore, this universal message is an eternal knowledge, permanence knowledge, dynamic and realize through individual’s intellectual knowledge development process. Thus, intellectual knowledge development is very crucial to strengthen the religios knowledge about the universal truth or spiritual growth process (Wan Mohd. Nor, 2005). Furthermore, it has becomes a guidance for the development of intellectual science which includes the physical, engineering and technical sciences (fard kifayah).

Those two categories of knowledge give great prominence on religious science because the former is said to be based on revealed teaching while the latter (intellectual science) is based on reason (Wan Mohd. Nor, 2005; Osman, 2006). Qutb Al-Din defines religious knowledge as the philosophical science that is the same, permanence and true for all times. The religious knowledge is about the nature of things that comprises the immutable or permanent aspects of the universe (Osman, 2006). The immutable aspect of the universe is well known as a law of nature. The law of nature is the Divine patterns which every creation runs, just like specific program created for every specific creation. They are immutable and their accomplishment is the whole universe and may be known by reason.

Al-Ghazali divides intellectual knowledge that is based on reason and empirical experience to mathematics, natural sciences, metaphysics and political science. Meanwhile, Al-Attas classifies this knowledge into eight broad disciplines which are the human sciences, natural sciences, applied sciences, technological sciences, comparative religion, western culture and civilization, linguistic sciences and Islamic history. However, Al-Attas does not confine the intellectual science to only eight broad disciplines above because knowledge, being an attribute of God is infinite. The intellectual science would also expand according to the needs and plans of a particular society. This category of knowledge should reflect the changing needs of the contemporary and the expected demands of the future (Wan Mohd. Nor, 2005). However, the development of intellectual knowledges should be guided by religious science. Nevertheless, Muslim scholars such as Al-Farabi, Al-Ghazali and Qutb Al-Din do not regard the distinction between sciences based on revelation and sciences based on reason and
empirical as dualistic because, even though divine knowledge is more superior to the intellectual knowledge, the former cannot be truly explained and elaborated without the latter. The latter without the former will be misguided. So they are complementary, though not equal to one another. Although the latter category is posterior, yet it is important when located in its proper place, whereby the former should become guidance to the latter knowledge. Therefore, education process should never neglect the scientific or intellectual or experimental knowledge (Osman, 2006).

Muslim scholars agreed that the highest knowledge hierarchy is the knowledge of God. It is for the sake of knowledge of God that all other forms of knowledge are hunted. Knowledge of all things other than God must be conceptually or organically related to the knowledge of God. This idea together with the view that all knowledge come ultimately from the same source constitutes it the idea of the unity of the Oneness of God (Osman, 2006). Figure 1 illustrates the concept of unity through the diversity of knowledge.

4. The Concept of Unity through Epistemology of Knowledge in Engineering Education

The epistemology of knowledge should be built based on universal ethical values and educators should play a leadership role in the creation of a knowledge-based society. According to Anis Ahmad (2009), this universal value (believe and faith in Allah S.W.T) should be placed at the top of the hierarchy of values which goes beyond religious, ethnic, linguistic and colour barriers. They are universal in their genesis and global and relevant to the whole of human. If we lose these values, we will lose humanity, culture and civility.

![Fig. 1. The unity concept through diversity of knowledge](image-url)
The following unity concepts are suggested as the principles of knowledge development process in engineering education:

4.1. **The unity in life**

If the purpose of education process is to systematically expose students to empirical data and train them in its classification and re-arrangement in order to meet the material needs of society, it cannot bring peace, harmony and fairness in human society. The education process only can produce functional, robotic human beings, create the students with excellent skills yet no unified vision, fragmented personality, conflict of interest, and contradiction in behaviour but deprived of love, justice, sacrifice honesty and truth.

In contrast, value based education concentrates on the development of holistic personality with no compartmentalize between faith, culture and technology. The value based education tends to integrate whatever values that are considered beneficial, and it moves around the central value of unity in life. The unity in life means elimination of contradiction, conflicts and dual standards of ethics and morality.

According to Anis Ahmad (2009), in Islamic life, the value of unity is the first principle of Islam, and it refers to the unity of Allah as the one and only. Everything else is separate and different from Him as a creator. He is the first and ultimate cause and end of everything. His will is the law of nature as well as the law of morality (Anis Ahmad, 2009). Moreover, according to Anis Ahmad, the message of unity in Islam is very simple; the compartmentalization in life or dualism thinker in order to serve diverse gods can never bring harmony, unity and cohesiveness in life. Therefore, the integration of this primary values will produce united and integrated thinkers who lives and thinks in consciousness of divine unity, which is Oneness of God as the ultimate and united vision.

The concept of unity also can be realizing as a divine pattern or the laws of nature upon which all creation runs. This divine pattern is immutable and their fulfilment is the whole universe. Mankind is the only creature that carries the divine trust of freedom to exercise his or her pure submission to God or not and carry the moral freedom of law (the law of morality), which constitutes *khalifah* (a leader to all God’s creation – leads the changes of the physical world) to God.

The main corpus of moral laws consists of actual way of life, of being, and social responsibilities. When what we do fulfils the moral requirement, it is good; when it does not, it is evil. Therefore, the deeds of mankind alone could be good or bad. It depend on whether their action will bring about justice, righteousness, beauty, happiness or otherwise. In other words, the fulfilment of *khalifah’s* responsibilities leads the changes in this world to the development and the establishment the culture of civilization. Therefore, mankind is God’s servant and God’s *khalifah* with the sense of unity of Allah is responsible to seek goodness, justice and the truth as a reference standard of morality in his action.

The sense of unity based on belief in Oneness of God will become a sieve to determine what is good or bad in the moral law of being. Therefore, education process could only produce high moral values human capital if the highest values which is belief in God is integrate properly cross every intellectual subjects in the curriculum. This is so call justice in positioning the proper place of God (the highest knowledge) in the order of knowledge.

4.2. **The unity of creation**

The unity of God’s creation has proven by the unity and the consistency of cosmic order. Every creation in the cosmos takes place by God’s command. Therefore, the cosmic order consists of the law of nature or Divine
pattern. The unity and the consistency of cosmic order enable mankind to recognize the permanence substances of things. Observation on the repetition of events that produce cause and effect relations help mankind to have better understanding about the meaning of existence of this universe. Finally, they will reach self understanding that everything has a purpose, never final, and always subject to other purpose where God is the ultimate cause and the ultimate end.

4.3. Unity of humanity

All mankind are one and the same. This is the basis that forms the groundwork of universal values in Islam. The mankind is one in the eye of Allah except their deeds that distinguish them in moral value and civilization achievement.

4.4. Unity of the truth and unity of knowledge

Allah has provided mankind with ability to reason (‘aql), as a tool to get to know and to think the world around him/her. The divine revelation is meant to guide the mankind to get knowledge. The revelation and reason are both complementary and essential for righteous life, to help mankind to understand their aims and fulfil their responsibilities. Therefore, there is no contradiction between revelation and reasoning.

The light of faith is definitely epistemological and is a consequence of reasonableness. Since Allah is the one and only Lord, truth cannot be equivocal. He knows the truth and in His revelation. What He conveys in the revelation cannot be different from reality, since He is the creator of all realities as well as all truth. The truth, which is the object of reason, is embodied in the laws of nature. These are the patterns of Allah’s creation, which are constant and unchangeable, possible to discover to establish and use for the benefit of humanity.

The logical equivalence of reason, truth, and reality is the fact of revelation. It is the most critical principle epistemology in Islam. The unity of truth prescribes that, there is no contradiction or variation between reason and revelation. When a researcher investigates nature in an attempt to discover the patterns of law of the creator in the universe, it is certainly possible to make mistakes. In other words, what the researcher perceived through his sense and the data that he had collected does not necessarily represent the ultimate reality (S. Imtiaz Ahmad, 1986). This would create discrepancy between revelation and reason.

However, according to the concept of the unity of truth, it rejects such discrepancy and demands that the researcher reinvestigate the data. The re-examination in the light of the principle of unity of truth will clear up the truth and rectify perception, thereby removing the contradiction between revelation, reality and its conception. The epistemology of knowledge in engineering education can be illustrated with the following figure (see Figure 2).
5. Conclusion

The challenges of engineering education today is not only to produce experts in engineering disciplines, but also to produce knowledgeable engineering education students who are able to integrate various scientific knowledge in problem solving process. The available teaching and learning strategies and curricula in the engineering education have shaped the engineering education students become dualist thinkers. In order to transform engineering education from dualism presentation of knowledge to the integration of knowledge, we need to understand the meaning of education and the concept of unity in epistemology of knowledge or knowledge development process. Therefore, the engineering education process which is very crucial in developing and preparing young generation with genuine intellectual, skills and attitudes as an engineer should develop beyond the range of traditional engineering curriculum. The eternal message of Unity should be well integrated with intellectual knowledge (technical and engineering education) so that our mission to produce first class young engineering generation will be accomplished.

References


