International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://www.TuEngr.com, http://go.to/Research

PEA Analysis: A Perspective Approach to Entrepreneurship Analysis in Engineering

Syamantak Saha [a*]

[a] *Information Architect Engineer*

ARTICLEINFO

Article history:
Received 23 August 2011
Accepted 02 November 2011
Available online
25 December 2011

Keywords:
Entrepreneurship,
Perspective Analysis,
Product Analysis.

ABSTRACT

As our technological capabilities increase, engineers have an increasing obligation to address market (societal) needs efficiently and sustainably. Such efficiency and sustainability is derived from entrepreneurial aspects of engineering solutions. Therefore, along with being a proponent of scientific solutions to societal/market needs, engineers also have to be effective entrepreneurs. The effectiveness of an engineering solution is not only measured by its scientific sophistication, but also its usefulness and contribution towards market (societal) needs. However, engineers seldom undertake entrepreneurial thinking whilst developing technology solutions, most efforts being expended on scientific sophistication. This is mainly due to the lack of suitable analysis technique that would enable engineers to undertake such evaluation. In this paper, a quantified perspective based analysis technique for evaluation of entrepreneurial engineering solution is presented called the PEA Analysis method.

1. Introduction

Engineers provide means for advancement of humanity by utilising scientific methods to address the needs of society (market demand). From building bridges to software technologies, engineers are involved in addressing the needs of society. Therefore, it is important that engineers create new and innovative solutions. However, it is not sufficient that an engineer

*Corresponding author (**Syamantak Saha**). E-mail addresses: ssaha@zapaat.com. ©2011 International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. Volume 2 No.5 (Special Issue). ISSN 2228-9860. eISSN 1906-9642. Online Available at http://TuEngr.com/V02/569-579.pdf

develop scientific solutions that are ultimately not utilised for society's benefit. A scientific invention is quite useless unless it is utilised appropriately for society's benefit, well beyond the experimental tables of the laboratory. Hence, it is important that engineers appreciate the entrepreneurship that exists inherently in engineering science. Without entrepreneurship, engineers would not appreciate the actual deficiencies of society and the demands of the market, and have the drive to present appropriate scientific solutions. An engineering solution is only useful to society, if it can be presented in an entrepreneurial manner. Otherwise, such efforts would only reduce to mere transactions in the scientific laboratory.

However, often engineers do not present an entrepreneurial solution to their innovation, as majority of Engineering Students do not receive adequate training in Entrepreneurship [1]. It is a common misconception that engineers are solely engaged in technical resolutions to real world problems. However, engineers accurately measure, develop and present solutions that are efficient, effective and sustainable for human development. Sociomaterial practices of business, knowledge and institutional entrepreneurship are synergistic [2]. Hence, an engineering solution is difficult to be presented effectively to society in an entrepreneurial manner by anyone else other than an engineer. In this paper, a perspective based method to evaluate entrepreneurship in engineering is presented, called the Perspective based Entrepreneurship Analysis (PEA) Method. This method is developed to assist Engineers design and develop solutions that encompass entrepreneurship in engineering.

1.1 Entrepreneurship in Engineering

Engineers address the market demand by finding scientific solutions that are for society's improvement. An engineering solution is useless unless it meets the market demands in a sustainable and efficient manner. Similarly, any entrepreneurial approach has similar considerations of acceptability and usefulness in society. Therefore, an engineer is an entrepreneur who addresses the market demands through scientific approaches to existing societal needs. Should the entrepreneurial elements and approach be compromised in an engineer, the advancement of society would be correspondingly effected due to engineering of unsustainable, inefficient and unuseful products.

Hence, effective engineers have effective entrepreneurial ability. Such ability and insight would be reflected in the engineering solutions that are provided, bringing a direct societal utility to the technology. If an engineer lacks such entrepreneurial abilities, then the solutions formed would not reach its full potential within society, unable to efficiently meet the market demands.

1.2 Literature Review

Entrepreneurship learnings at Universities are a recent phenomenon [1][2][3][4][5]. Engineers were mainly trained in skills such as mathematics, physics and sciences, without much

stress on entrepreneurship aspects of engineering in the curriculum. However, with the advances of technology, the complications of sustainably delivering complex technological solutions can be managed most effectively by personnel who fully understand such complexities. Hence, the most effective managers of technology prove to be the engineers who develop such technology, since the drive to be sustainable becomes increasingly interwined with the technological prowess of the engineering solution. Hence, engineering business requires not only technology development, but the actual delivery of such products and services to mankind. Separation of engineering and entrepreneurship in technology solutions makes the technology unaware of the market demands, defying the core objective of engineering - to address the needs of society. Moreover, engineering business failures are often deemed as a technology failures, making mankind wary of innovation and engineering.

National Science Foundation (NSF) recognises this need for entrepreneurship training to engineers and has sponsored sessions at Universities [3]. Such education entailed engineers to undertake a project where they develop a product/service and then present it to customers. However, such efforts are a training session for engineers to learn how to sell their products. Inevitably, this effort to market or sell an engineering product can be better undertaken by marketing and business professionals, who are better taught to perform such activities. Therefore, such training exercises for engineers are likened to an awareness of how marketing and business work, incomplete of a university education on entrepreneurship. As engineers learn mathematics at the core of engineering, entrepreneurship should similarly be included as part of the core curriculum. It is inadequately addressed by a one-off sales and marketing training, as is observed to be provided in such sessions. As an engineering student undertakes university courses to educate the mind about technology, similar education should be undertaken to develop the entrepreneurship skills of the engineer, without the traditional differentiation - technology is for engineers and entrepreneurship is for business/marketing students, as such differentiation becomes blurred with the increasing complexities of technology, falling upon the engineer to resolve all business issues should and when technology fail. Hence, an engineer should be well conversant and already proactive in the business of entrepreneurship in engineering, to create the most efficient, sustainable and profitable innovative engineering business. Currently, engineers are untrained on entrepreneurship aspects, despite the occasional sponsored sessions by organisations such as the NSF. Surveys conducted confirm that engineering graduates feel that they did not receive formal education in entrepreneurship [1].

Universities have developed courses for engineers that include subjects such as entrepreneurship in engineering [4]. However, such curriculum involves undertaking couple of

*Corresponding author (**Syamantak Saha**). E-mail addresses: ssaha@zapaat.com. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. Volume 2 No.5 (Special Issue). ISSN 2228-9860. eISSN 1906-9642. Online Available at http://TuEngr.com/V02/569-579.pdf

subjects on entrepreneurship. It still lacks the thorough business training for engineers, that is given to marketing and business majors. Universities have mainly developed entrepreneurship training for engineers with stress on creativity, innovation and leadership, without any mention of business management [5]. Therefore, the core idea of how to develop entrepreneurial engineering still remains undelivered to majority of engineering students.

1.3 Engineering with Entrepreneurship

An engineer realises a need in society and develops scientific solutions to address it. So for an engineer to develop an entrepreneurial solution, he/she has to have a direct and relevant link to the specific societal need that is being attempted to be addressed. The entrepreneurship in engineering would therefore be derived from the strength of association of the engineering solution to the societal needs and market demands that it addresses. A strong association would have high entrepreneurship, and a weak association would have a corresponding low entrepreneurship value.

Therefore, to engineer effectively with entrepreneurship, an engineer has to be able to correlate and associate the perspectives of the societal needs (market demand) with the perspectives of the engineering solution. A method to match such societal and engineering perspectives would ultimately render a scientific solution that is entrepreneurial by virtue of its usefulness and utility in society.

1.4 Purpose of this Paper

Engineers are directly responsible for the improvement and advancement of society. This responsibility is undertaken by engineers in the development of innovative technology that improves lives. However, increasingly, engineers need to provide such innovation in a sustainable manner that meets market demands. Therefore, to only develop an innovative solution has become partial to the responsibilities of the engineer. Now, an engineer also has to ensure that the innovation is entrepreneurial, such that optimal benefit of the innovation can be derived by humanity over time.

For an engineer to be entrepreneurial, it requires effort from university education to gaining a thorough understanding of the demands of the industry. Therefore, the idea of engineering ranges from a pure technical innovator to a full entrepreneur, depending on the interests of the engineer, as the engineering discipline is embedded with seeds for both.

However, engineers have inherent understanding of entrepreneurship. Through the analysis of the needs of society, an engineer develops and innovates technological solutions. This is the same notion that drives sustainable entrepreneurship, where a business is profitable when it can

meet the needs of society. Therefore, there is an intersection of the core values of entrepreneurship and engineering, where both strive to identify the needs of society, assemble appropriate resolution and make it available to society for its improvement.

Although engineers are well versed in the application of technology for benefit of mankind, it can be further clarified if an engineer has a method to evaluate and validate an engineering idea for its benefit to society. Mostly such assessment has involved the initiative of a businessman and the technical capabilities of the engineer, the two amalgamating to form sediments, although tangible, but not without the residue of inefficiencies.

Such that engineers can evaluate the entrepreneurship value of their innovation, this paper introduces a method to directly co-relate innovation and engineering with societal benefits. It adds to the existing body of knowledge by introducing a mathematical method for engineers to consider.

2. Statistical Methods – PEA Analysis

Using a combination of human reasoning and statistical computation, extremely complicated problems have been resolved [6][7]. Statistical methods have been successfully utilised to address such complicated issues in several diverse areas [8][9].

PEN Analysis [10], provides a method to derive a quantitative value for a Perspective (P), from Events (E) and Needs (N) that form the Perspective. It is formulated that the basis of every Perspective is due to attributable Events and Needs, without which the Perspective would not exist.

2.1 Formulas

A quantitative value of an Event (EVal) is a product of the probability of an Event occurring and the confidence on this probability. Therefore, suppose a Perspective is held as:

Perspective

P1: Email is an efficient method of formal communication.

For this Perspective, the causing Events are that from the last ten occurrences of formal communication via email, eight times, the communication was transmitted and received successfully. Also, the confidence on this probability is 0.9. Therefore, a quantitative value for the Event, or its EVal is:

*Corresponding author (**Syamantak Saha**). E-mail addresses: ssaha@zapaat.com. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. Volume 2 No.5 (Special Issue). ISSN 2228-9860. eISSN 1906-9642. Online Available at http://TuEngr.com/V02/569-579.pdf

EVal = Chance of Occurrence * Confidence

= 8/10 * 0.9 = 0.72

A quantitative value for a Need (NVal) of an Organisation is the weightage attributed to the Need according to the Perspective that it addresses. Hence, the Need for the above example Perspective is to send formal communication efficiently. Therefore, the Need Value, or its NVal is the weightage attributed to it of 0.7.

NVal = Organisational Weightage of Need from P1

= 0.70

As the Perspective P1 is formed of and directly related to the Event and the Need, it is derived that: P is directly proportional to E and N: Therefore, the Perspective Value (PVal) is:

$$PVal = k * EVal * NVal \quad [1]$$

where k is an arbitrary constant, to convert proportionality to equality. And,

$$PVal(Px) = k * ((PrE(E1)*wN(N1)) + .. + (PrE(En)*wN(Nn))) \quad [2]$$

where E is an Event and N is a Need for the Organisation.

Hence, the Perspective Value of the Perspective P1 can now be calculated using formula 1 as:

$$PVal(P1) = EVal * NVal = 0.72 * 0.70 = 0.50$$

2.2 PEA Method Derivation

Let us assume that an Engineer identifies a societal need that can be addressed with a scientific solution.

Societal/Market Need

SN: Societal Need to be addressed with Engineering

For this societal (market) need, let us assume that the corresponding perspectives are:

Standard Perspectives

SP1: Standard Perspective 1 for SN
SP2: Standard Perspective 2 for SN
SP3: Standard Perspective 3 for SN
SP4: Standard Perspective 4 for SN

Using PEN Analysis, the perspective values (PVals) for the above Standard Perspectives are calculated with the societal/market perceptions. Accordingly, let us suppose that the corresponding PVals are calculated as:

PVals(Market)

PVal(MSP1): Perspective Value for SP1 attributed by market
PVal(MSP2): Perspective Value for SP2 attributed by market
PVal(MSP3): Perspective Value for SP3 attributed by market
PVal(MSP4): Perspective Value for SP4 attributed by market

Now, when an engineer develops a scientific solution to this Societal Need (SN), the value on the Standard Perspectives (SP) as attributed by societal/market perceptions, has to be compared with the value attributed by the engineer in the engineered solution. Suppose the PVals on the Standard Perspectives for the engineering solution are calculated as:

PVals(Engineer)

PVal(ESP1): Perspective Value for SP1 attributed by engineer
PVal(ESP2): Perspective Value for SP2 attributed by engineer
PVal(ESP3): Perspective Value for SP3 attributed by engineer
PVal(ESP4): Perspective Value for SP4 attributed by engineer

Next, we proceed to calculate the Average of the Perspective Values for the two lists.

$$Avg(Market) = (PVal(MSP1) + PVal(MSP2) + PVal(MSP3) + PVal(MSP4))/4$$

$$Avg(Engineer) = (PVal(ESP1) + PVal(ESP2) + PVal(ESP3) + PVal(ESP4))/4$$

The Vicinity of two numbers reflect the proximity of the two numbers from each other. Therefore, if we calculate the Vicinity of the two Averages, then we will find the degree of match of the Standard Perspectives with that of the engineering solution.

$$X = Avg(Market)$$

$$Y = Avg(Engineer)$$

$$Vicinity = ((X-Y)/X) * 100$$

If the Vicinity is less than 25% then the engineering solution is entrepreneurial, as it addresses the societal/market needs effectively, as reflected by the proximity of the perspective values.

2.3 PEA Case Study: Entrepreneurship of an Email System

We can now proceed to further illustrate PEA Analysis with a case study that considers the general innovation and engineering of an email system. The selected case study describes the

*Corresponding author (**Syamantak Saha**). E-mail addresses: ssaha@zapaat.com. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. Volume 2 No.5 (Special Issue). ISSN 2228-9860. eISSN 1906-9642. Online Available at http://TuEngr.com/V02/569-579.pdf

analysis that can be undertaken using PEA Analysis to evaluate the entrepreneurship value of the engineering and innovation of email systems.

Societal/Market Need

SN: Send and receive messages via the internet

The Standard Societal Perspectives for this need are:

Standard Perspectives

SP1: Send and receive messages instantly
SP2: Send and receive messages at a low cost
SP3: Store messages that have been received and sent
SP4: Forward received messages with ease

Accordingly, we calculate the PVals for the above Standard Perspectives (SP) with societal/market perceptions. These values can be collected by directly querying the customers in the market and/or analysing related market data.

PVals(Market)
PVal(SP1) = 0.8
PVal(SP2) = 0.9
PVal(SP3) = 0.7
PVal(SP4) = 0.7

The identified societal need would have an entrepreneurial engineering solution if such a solution closely matches the values attributed by the market to the Standard Perspectives. So, the value attributed by the Engineer on the Standard Perspectives to form the Engineering solution, is now calculated by analysing the Engineered product.

PVals(Engineer)
PVal(ESP1) = 0.7
PVal(ESP2) = 0.9
PVal(ESP3) = 0.7
PVal(ESP4) = 0.9

Next, the average values of the above lists are calculated.

Avg(Market)	= (PVal(MSP1) + PVal(MSP2) + PVal(MSP3) + PVal(MSP4))/4
	= (0.8 + 0.9 + 0.7 + 0.7)/4 = 3.1/4 = 0.78
Avg(Engineer)	= (PVal(ESP1) + PVal(ESP2) + PVal(ESP3) + PVal(ESP4))/4
	= (0.7 + 0.9 + 0.7 + 0.9)/4 = = 3.2/4 = 0.80
Vicinity	= ((0.78 – 0.80)/0.78) * 100 = 2.5%

As the Vicinity value is less than 25%, the engineering solution meets the societal need to send messages efficiently.

3. PEA Framework

A PEA Framework for Entrepreneurship analysis of Engineering solutions can now be

presented in Figure 1.

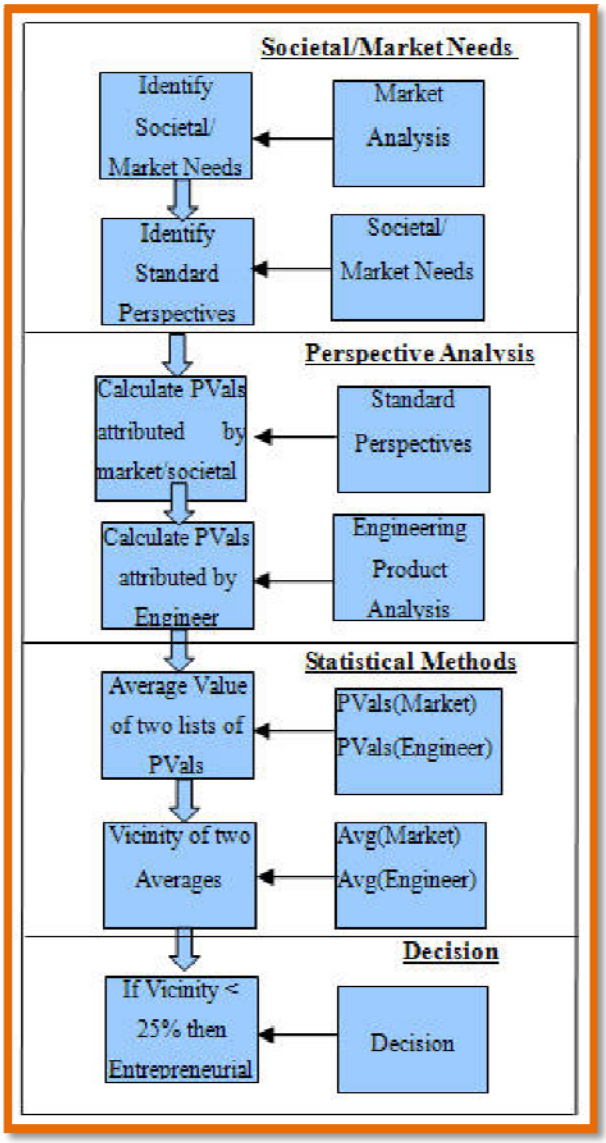

Figure 1: PEA Analysis Framework for Entrepreneurship Analysis in Engineering Solutions.

4. Discussion

Often an Engineering solution is taken by its scientific merit, assuming that if a solution is a scientific marvel, then it would automatically have a high market value. However, such expectations of entrepreneurial engineering based on scientific merits, could become a disappointment when presented to the market. When such engineering ventures become a failure, it is thought that there were shortcomings in the technology and that the technology did not provide adequately. However, it is not always clear as to what exactly the technology did not provide. Seldom enough analysis and understanding of the entrepreneurship failures of

*Corresponding author (**Syamantak Saha**). E-mail addresses: ssaha@zapaat.com.
International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. Volume 2 No.5 (Special Issue). ISSN 2228-9860. eISSN 1906-9642. Online Available at http://TuEngr.com/V02/569-579.pdf

engineering is undertaken that would provide a basis for improvement of entrepreneurial engineering efforts.

As considerable effort is expended in developing an Engineering solution, it is important that Engineers have an initial understanding of the expected entrepreneurship in the product. Often, effort is given to making an engineering solution a scientific marvel, assuming the market will automatically allocate a high demand to such products. However, this direct correlation between scientific marvel and product success is not fully accurate. A critical aspect for the success of any engineered product is how well it meets the market demands for a societal need. When a product is developed with high affiliation to a market need, the expected success of the product is much more than if it were based only on scientific marvel.

5. Conclusion

Engineers develop solutions that address a need of society. Therefore, it is essential that engineers develop scientific solutions that are sustainable and presentable to society to address such needs. Inherently, this brings about an entrepreneurial aspect to engineering solutions. If an engineering solution is not entrepreneurial, then the need of the society is not appropriately met. Hence, to develop an engineering solution, engineers need to consider such entrepreneurial aspects in scientific solution design.

However, engineers mostly engage in solution development from a technical aspect. Seldom, an engineer engages entrepreneurial aspects into their solution design. Should engineers incorporate such aspects into their solutions, then the ultimate engineering for societal need would be sustainable at the core towards the development of society.

Due to the lack of any analysis method to evaluate entrepreneurial aspects in engineering, engineers often overlook such an important element in scientific solutions. In this paper, a quantified perspective based evaluation technique for entrepreneurial engineering solutions is presented, the PEA Analysis method. Using this technique, engineers can design and develop solutions that incorporate the societal needs at the core, thereby rendering engineering solutions that are sustainable and effective for human development.

6. References

[1] M.; Sanchez-Ruiz, L.M.; Tovar-Caro, E.; Ballester-Sarrias, E. 2009.Engineering students' perceptions of innovation and entrepreneurship competences: Edwards*Frontiers in Education Conference, 2009. FIE '09. 39th IEEE:*, pp. 1-5

[2] Davidson, E.; Vaast, E.; 2010. Digital Entrepreneurship and Its Sociomaterial Enactment: *System Sciences (HICSS), 2010 43rd Hawaii International Conference on;* pp.1 – 10

[3] Luryi, S.; Wendy Tang; Lifshitz, N.; Wolf, G.; Doboli, S.; Betz, J.A.; Maritato, P.; Shamash, Y. 2007. Entrepreneurship in engineering education; *Frontiers In Education Conference - Global Engineering: Knowledge Without Borders, Opportunities Without Passports, 2007. FIE '07. 37th Annual;* pp. T2E-10 - T2E-15

[4] Schultz, R.R.; Johnson, A.F.; Dougan, W.L.; Wambsganss, J.R.; Chang-Hee Won; Giesinger, B.G.; Osburnsen, P.P.; Timpane, T.J.; 2002. An entrepreneurship minor/cognate for engineering graduate degrees; *Frontiers in Education, 2002. FIE 2002. 32nd Annual* Volume: 2; pp. F1H-1 - F1H-6.

[5] Doboli, S.; Tang, W.; Ramnath, R.; Impagliazzo, J.; VanEpps, T.; Agarwal, A.; Romero, R.; Currie, E.H.; 2010. Panel — Models of entrepreneurship education and its role in increasing creativity, innovation and leadership in computer science and engineering students; *Frontiers in Education Conference (FIE), 2010 IEEE;* pp. F1B-1 - F1B-4.

[6] Khushaba, Rami N.; Al-Jumaily, Adel; Al-Ani, Ahmed. 2008. Fuzzy discriminant analysis based feature projection in myoelectric control : *Engineering in Medicine and Biology Society, 2008. EMBS 2008. 30th Annual International Conference of the IEEE*, pp.5049 – 5052

[7] Hung Nguyen; Hung, W.T.; Thornton, B.S.; Thornton, E.; Lee, W. : 1998. Classification of microcalcifications in mammograms using artificial neural networks : *Engineering in Medicine and Biology Society, 1998. Proceedings of the 20th Annual International Conference of the IEEE*, Vol.2. pp.1006 - 1008

[8] Clearwater, S.H.; Provost, F.J. 1990. RL4: a tool for knowledge-based induction: *Tools for Artificial Intelligence, 1990. Proceedings of the 2nd International IEEE Conference*. pp.24-30.

[9] Ramaesh, B.; Dhar. V. 1994. Representing and maintaining process knowledge for large-scale systems development : *IEEE Expert Volume: 9 , Issue: 2:* pp.54 – 59.

[10] Saha, Syamantak 2010. PEN Analysis – A Perspective approach to business process integration; Chapter 2: *A Perspective Approach to Global Business Decisions*; ISBN: 978-0615425825.

Syamantak Saha is an Information Architect and has worked as a consultant at several organisations. He has a Bachelor of Computer Science and a Master of Engineering. Currently he is working towards his doctorate and his research interest is in applied statistics for organisation management.

Peer Review: This article has been internationally peer-reviewed and accepted for publication according to the guidelines given at the journal's website. Note: The original work of this article was accepted and presented at IAJC-ASEE International Joint Conference on Engineering and Related Technologies sponsored by IAJC, ASEE, and IEEE, venue at University of Hartford, USA during April 29-30, 2011.

*Corresponding author (**Syamantak Saha**). E-mail addresses: ssaha@zapaat.com.