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Employing Fuzzy Delphi Method to Validate Communication Skills among Engineering Graduates

Amarjit Singh [a,1]
Azrul Fazwan Kharuddin [a,2]
Zaida Mustafa [a,3]

[a] Universiti Tun Abdul Razak, Kuala Lumpur, Malaysia

[1] s.amarjit203@ur.unirazak.edu.my
[2] azrulfazwan@unirazak.edu.my
[3] zaida@unirazak.edu.my

Abstract

Delphi method is a technique and structured approach used to review and collect opinions of a group of experts, however, has its own weaknesses. The Fuzzy Delphi Method (FDM), derived from a modifications of Delphi method, considered by many researches as more superior in providing evidence of human linguistic (which is the signature of Delphi Technique). In this paper, Fuzzy Delphi Method was used to assess the content of communication skills among engineering graduates. This development phase is a part of a project to develop an engineering employability skill framework in Malaysia. The paper presented the result of the experts' view and the appropriateness of Fuzzy Delphi Method as an important tool to provide information about the validity of communication skills content. Experts' perceptions have shown incongruity with respect to speak and understand more than one language among engineers. The experts agreed with engineering graduates might be give a clear direction, listen and ask question in their employability skills proficiency. This phase involves the view of 10 experts who are experienced and have deep knowledge in engineering. It is a rigorous statistical analysis to validate the validity of abstract concept of the communication skills.

Keywords: Fuzzy Delphi Method, Validation, Communication Skills, Engineering Employability

Introduction

The Fuzzy Delphi method was proposed by Murray, T., Pipino, L., & Vangigch, J. (1985) with the idea of combining the traditional Delphi method and Fuzzy Set theory. The standard Delphi method developed by Dalkey and Helmer (1963) was the most relied upon methodology used to find answers within a set of questionnaires (Lin & Hwang, 1987; Reza & Vassilis, 1988). This method was based on the use of linguistic terms. However, because of the potential for misunderstandings between the meanings of the answers taken from the questionnaires and the interpretation of these answers by experts, in many situations, this approach resulted in uncertainty and was not properly able to reflect quantitative terms. Experts attempted to address this 'fuzziness' in terms of understanding the outputs of the Delphi method using the Fuzzy Set theory (Ansari et al., 2019). The Fuzzy Set theory is an approach that can resemble human reasoning in its use of approximate information and uncertainty to generate decisions. It was specifically designed to mathematically represent

uncertainty and vagueness and provide formalized tools for dealing with the imprecision intrinsic to many problems (Zadeh et al., 1996; Ung et al., 2006; Bozbura et al., 2007). In this analysis, the efficiency of interpreting questionnaire results could be much improved through objective evaluation of the factors that the Fuzzy Set theory proposes. To improve the weaknesses associated with theories, Murray, T., Pipino, L., & Vangigch, J. (1985) proposed to integrate them. However, it was Ishikawa et al. (1993) who combined specialists' opinions with fuzzy numbers based on the concepts of cumulative frequency distribution and the fuzzy integral. This process is called the Fuzzy Delphi method (FDM). The main steps of FDM include the following: 1) Fuzzification; 2) Fuzzy evaluation; 3) Triangular fuzzy numbers; and 4) Defuzzification. To date, FDM has been extensively used in diverse fields of studies, including urban planning, regional road safety, urban road safety, service industries, and health, among others (Yusoff et al., 2021).

The purpose of this study was to examine the level of consensus among 10 Malaysian experts in the field of engineering regarding the communication skills among engineering graduates, specifically in the Malaysian context using the Fuzzy Delphi Method. The following was the research question: What do experts believe are the potential of communication skills in the context of engineering graduates?

Literature Review

Fuzzy Delphi Method is a combination between Delphi classic method and fuzzy set theory. The method was introduced by Lotfi Zadeh in 1965, an expert in mathematics (Zadeh, 1965). The Fuzzy set theory mechanism act as a leeway of the classic set theory in which each element in a set is evaluated based on the binary set of "Yes" or "No". According to Bodjanova (2005) the values for numbering fuzzy are between 0 to 1 or if in the unit interval of (0, 1). It has been proven in previous literature review that FDM has been used as a method in various areas, as in engineering, education and many other professional fields. In addressing this issue, an introduction of communication skills is pivotal. Communication is a strategic sill that exclusively considers purpose, content and context of communication to effectively deliver information in working field (Cook et al., 2002; Lappalainen, 2010; Rau et al., 2014). These skills can be categorized into five: a) speak, b) give direction, c) listen and ask question, d) ideas and e) understanding skills (Cook et al., 2002; McMurrey, 2002; Brinkman & van der Geest, 2003; Reaves et al., 2005; Lappalainen, 2010; Rau et al., 2014). Findings of previous studies have appointed its importance in preparing students for real communication in industry (Reaves et al., 2005; Lappalainen, 2010; Rau et al., 2014).

Methodology

The purpose of this study is to validate the content of communication skills among engineering graduates using Fuzzy Delphi Method (FDM) via experts' feedback. Ten experts who are experienced and have deep knowledge in engineering involved in this study. Fuzzy Delphi Method Procedure was selected to validate the content of the communication skills among engineering graduates. Fuzzy Delphi Method (FDM) is used to identify, evaluate and confirming all the key components and contents of the communication skills according to three terms of the experts' agreement which are threshold (d) value, percentage of expert agreement and the value of Fuzzy Score (A). Data analysis uses average of fuzzy numbers (defuzzification process). In this analysis is aimed to get the score of fuzzy score (A) to ensure the third condition is observed, the value of the fuzzy score (A) must be greater than or equal to the median value (α - cut value) of 0.5 (Bodjanova, 1997; Bodjanova, 2006; Tang & Wu, 2010;). This indicates that the element is accepted by an expert agreement. Among other functions, the value of fuzzy scores (A) can be used as a determinant and priority of an element according to expert opinion views.

Approach to FDM

After the questionnaires were administered, the third phase of the study was the application of the FDM. Based on the questions asked in the questionnaires, the main criteria and their ranking of importance were selected by 10 professionals in different fields of studies, such as executive, civil engineers, businessman, and technical & vocational.

Step 1: The first fuzzy system was designed to understand communication skill quality among engineering graduates, the second one was to understand the engineering student's quality, and the third one was to understand if there was a real need for engineering programme restructuring.

Table 1: Communication Skills Assessment Threshold Value

Sub-skill	Threshold Value (d)
CS_1 : Communication skills : [Speak in clear Sentences]	0.183
CS_2 : Communication skills : [Give clear direction]	0.147
CS_3 : Communication skills : [Listen and ask question]	0.147
CS_4 : Communication skills : [Ideas presented with confident and effective]	0.214
CS_5 : Communication skills : [Speak and understand more than one language]	0.189

Based on Table 1, there is one threshold value highlighted in red that is passed over the threshold cut-off value of 0.2 (> 0.2) and four threshold value is below than 0.2. If the average value of threshold (d) is less than 0.2, the item has reached a good expert agreement (Chang et al., 2000; Chang, Hsu and Chang, 2011; Kharuddin et al., 2019).

Fuzzification

The aim of the fuzzification step is to determine the mapping degree of crisp inputs to fuzzy sets using membership functions. In the communication skills Fuzzy system, five inputs were used, namely: 1) Speak in clear Sentences; 2) Give clear direction; 3) Listen and ask question; 4) Ideas presented with confident and effective; and 5) Speak and understand more than one language. These input yielded one output: communication skills assessment. The level of agreement for the communication skill among engineering graduates were highly important, important, somewhat important, least important and not important at all. The levels of the expert consensus on communication skills were very optimistic, neutral and very pessimistic.

Step 2: Calculate the fuzzy average $A\tilde{V}G_{ALL}$ and re-examine (if necessary for each dataset which represent consensus adjustment obtained as

$$A\tilde{V}G_{ALL} = \begin{bmatrix} 0.700 \\ 0.720 \\ 0.720 \\ 0.660 \\ 0.540 \end{bmatrix}$$

Step 3: Measure the level of confidence results using alpha (α)-cuts concept via three linguistic variables as defined in Table 3 and employ by Equation (2) as shown in Table 4.

Table 3: Threshold Value (d), Percentage of Expert Consensus (%) And Fuzzy Score (A) for Communication Skill

EXPERTS	Communication Skill (CS)				
	1	2	3	4	5
1	0.2	0.2	0.2	0.4	0.5
2	0.2	0.1	0.1	0.2	0.2
3	0.2	0.1	0.1	0.2	0.1
4	0.5	0.2	0.2	0.4	0.1
5	0.2	0.1	0.1	0.2	0.1
6	0.2	0.1	0.1	0.1	0.4
7	0.2	0.1	0.1	0.2	0.1
8	0.2	0.1	0.1	0.2	0.1
9	0.2	0.2	0.2	0.1	0.2
10	0.2	0.2	0.2	0.1	0.1
Average of Threshold Value (d)	0.183	0.147	0.147	0.214	0.189
Percentage of Experts Consensus (%)	**90.0%**	**100.0%**	**100.0%**	**80.0%**	**80.0%**
Fuzzy Score (A)	**0.700**	**0.720**	**0.720**	**0.660**	**0.540**

While this percentage of the overall agreement is at a value of 90% of the agreement above 75% means meeting the terms of the expert agreement on this item. The highest value of defuzzication evaluation is 0.720 and the lowest is 0.540. In addition, all Alpha-Cut defuzzication (average of fuzzy response) exceeds α-cut ≥ 0.5. According to Mamat et al., (2018) and Hashim et al., (2020) the cut-off value should exceed 0.5. If the value is less than 0.5, the item should be dropped. This show the subjects of subjective norms have good experts' agreement on item assessment. The items agreed by the expert consensus are arranged according to the ranking as shown in Table 4.

Step 4: Defuzzify average fuzzy set using Equation (3), and apply adjustment the results (if necessary).

Table 4: The crisp values for four levels of confidence and the ranking

Level of confidence	Very Pessimistic (VP)	Neutral (N)	Very optimistic (VO)	Ranking
CS_5	0.340	0.540	0.740	
CS_4	0.460	0.660	0.860	

CS_3	0.520	0.720	0.920	$CS_2 = CS_3 > CS_1 > CS_4 > CS_5$
CS_2	0.520	0.720	0.920	
CS_1	0.500	0.700	0.900	

Notes: '>' means is 'superior to', '=' means is 'equivalent to'

Step 5: Ranking process by descending order. As we can see that, from Table 4 (see last column) issue CS_2 (Give clear direction) are preferred and the last choice is the fifth issue (CS_5 – Speak and understand more than one language) in terms of their consent on engineering students' communication skill. This ranking result is consistent at every level of confidence that it was imposed.

Table 5**:** Result of experts' consensus using Fuzzy Delphi Method (FDM) for Communication Skills (CS)

Communication Skill (CS)								
Item	Sub-skill	*Triangular Fuzzy Numbers*		*Defuzzification Process*				Experts Concencus Decision
		Threshold Value (d)	Average Percentage of Expert Concensus (%)	m1	m2	m3	*Fuzzy Score (A)*	
1	1. Communication skills : [Speak in clear Sentences]	0.183	90.0%	0.50	0.70	0.90	0.50	ACCEPT
2	2. Communication skills : [Give clear direction]	0.147	100.0%	0.52	0.72	0.92	0.52	ACCEPT
3	3. Communication skills : [Listen and ask question]	0.147	100.0%	0.52	0.72	0.92	0.52	ACCEPT
4	4. Communication skills : [Ideas presented with confident and effective]	0.214	80.0%	0.46	0.66	0.86	0.46	REJECT
5	5. Communication skills : [Speak and understand more than one language]	0.189	80.0%	0.34	0.54	0.74	0.34	REJECT

Conditions for ACCEPT:
1) Threshold Value (d) ≤ 0.2
2) Average Percentage of Expert Consensus (%) $\geq 75.0\%$
3) Fuzzy Score (%) ≥ 0.5

Based on table 5, the Fuzzy Delphi analysis identified that a significant number of experts had strongly negative consent about communication skills among engineering graduate. Experts' perceptions have shown incongruity with respect to speak and understand more than one language (lowest defuzzification score of 0.34). They also held contradictory opinions on the ideas presented with confident and effective in the Malaysian context (0.46 points). This stipulates a mismatch between the rhetoric of integrating communication skills into the field and the reality of its implementation. This is parallel to the Zaini and Mansor (2010) study findings that Malaysian engineering graduates still need to improve their communication skills, although they were mainly aware of the potential of employability preserve. The experts agreed with engineering graduates might be give a clear direction, listen and ask question in their employability skills needed (highest defuzzification score of 0.52). They also acknowledged speak in clear sentences as an element of communication skills needed for engineering graduates (Kharuddin et al., 2018). The positive views collected are in line with a study by Antheunis et al. (2013), where the key barrier in communication skills among most engineer practitioners was its effectiveness.

Discussion

The purpose of this study was to examine the extent of experts' consensus on the communication skills among engineering graduates. There are 5 communication skills which carried out employability skills elements in the engineering framework. Researcher has selected five sub-skills (CS_1 – CS_5) to show the result of experts' consensus in communication skills among engineering graduates. In order to strengthen each element in the main component to meet its requirements in the context of the study, the process of assessing and validating of the communication skills among engineering graduates, the agreement of experts was analysed by Fuzzy Delphi Method (FDM). The use of FDM approach in this phase is to evaluate and validate the developed elements. It is clearly shown the significant level of agreement requirements for each element in the employability skills framework. Therefore, the most significant contribution to the methodology involves in this study is the use of the Fuzzy Delphi (FDM) approach in developing a employability skills framework based on the views of a group of experts comprising of practitioners, management personnel in engineering and industrial representatives. As a result of the used of FDM, the findings show that there is an acceptable expert's agreement on the content of the communication skills among engineering graduates focusing on speak in clear sentences, give clear direction, listen and ask question.

Theoretical and Contextual Contribution

This research comprises a selection of variables from an engineering employability skill framework in Malaysia on theoretical advances and applications of fuzzy logic computing. These variable name communication skills were selected from over 14 competency skills and constitute an important contribution to the theory and applications of fuzzy logic methodologies. Fuzzy Delphi computing consists of several computing paradigms, including fuzzy logic, neural networks, genetic algorithms, and other techniques, which can be used to produce powerful intelligent systems for solving real-world problems. Applications range from pattern recognition to intelligent control and sow the advantages of using fuzzy delphi computing theory and methods. This paper also makes a contribution to this goal.

References

Ansari, Z., Zaini, S. H. R., & Akhtar, A. (2020, November). Identification of Alternative Insurance Model using Fuzzy AHP. In *Financial Issues in Emerging Economies: Special Issue Including Selected Papers from II International Conference on Economics and Finance, 2019, Bengaluru, India*. Emerald Publishing Limited.

Antheunis, M. L., Tates, K., & Nieboer, T. E. (2013). Patients' and health professionals' use of social media in health care: motives, barriers and expectations. *Patient education and counseling*, *92*(3), 426-431.

Bodjanova, S. (1997). Approximation of fuzzy concepts in decision making. *Fuzzy sets and systems*, *85*(1), 23-29.

Bodjanova, S. (2005). Median value and median interval of a fuzzy number. *Information sciences*, *172*(1-2), 73-89.

Bodjanova, S. (2006). Median alpha-levels of a fuzzy number. *Fuzzy Sets and Systems*, *157*(7), 879-891.

Bozbura, F. T., Beskese, A., & Kahraman, C. (2007). Prioritization of human capital measurement indicators using fuzzy AHP. *Expert systems with applications*, *32*(4), 1100-1112.

Brinkman, G. W., & van der Geest, T. M. (2003). Assessment of communication competencies in engineering design projects. *Technical communication quarterly*, *12*(1), 67-81.

Chang, P. T., Huang, L. C., & Lin, H. J. (2000). *The fuzzy Delphi method via fuzzy statistics and membership function fitting and an application to the human resources.* Fuzzy sets and systems, 112(3), 511-520.

Chang, P.L., Hsu, C.W., & Chang, P.C. (2011). *Fuzzy Delphi method for evaluating hydrogen production technologies.* International Journal of Hydrogen Energy. 14172–9.

Cook, T. D., Campbell, D. T., & Shadish, W. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston, MA: Houghton Mifflin.

Dalkey, N., & Helmer, O. (1963). An experimental application of the Delphi method to the use of experts. *Management science*, *9*(3), 458-467.

Hashim, M. E. A., Idris, M. Z. B., & Said, C. S. B. (2020). *Applying Fuzzy Delphi Method (FDM) to obtaining the Expert Consensus in Aesthetic Experience (AX) and User Experience (UX) Elements in Augmented Reality Comic (AR Comic).* Psychology and Education, 57(8), 956-962.

Ishikawa, A., Amagasa, M., Shiga, T., Tomizawa, G., Tatsuta, R., & Mieno, H. (1993). The max-min Delphi method and fuzzy Delphi method via fuzzy integration. *Fuzzy sets and systems*, *55*(3), 241-253.

Kharuddin, A. F., Kamaruddin, S. A., Kamari, M. N., Mustafa, Z., & Azid, N. (2018). *Determining important factors of arithmetic skills among newborn babies' at Malaysian taska using artificial neural network.* Southeast Asia Early Childhood Journal, 7, 33-41.

Kharuddin, A. F., Mustafa, Z., Azid, N., Kharuddin, D., Ku Ibrahim, K. F., Hong, L. Y., Syed Mohmad, S. O., & Zahri, Z. A. (2019). *Comparison of registration status of Institutional Taska services in East Coast Malaysia.* Southeast Asia Early Childhood Journal, 8(2), 57-62.

Lappalainen, P. (2010). Integrated Language Education –A Means of Enhancing Engineers' Social Competences. European Journal of Engineering Education, 35/4,pp.393-403

Lin, C. S., & Hwang, C. L. (1987). New forms of shape invariants from elliptic Fourier descriptors. *Pattern recognition*, *20*(5), 535-545.

Mamat, C. L. C., & Yunus, H. (2018). *Early exploration of Forest School framework for Malaysian Indigenous People: The Application of Fuzzy Delphi Technique.* Int. J. of Multidisciplinary and Current research, 6.

McMurrey, D. A. (2002). *Power tools for technical communication*. Harcourt College Pub..

Murray, T., Pipino, L., & Vangigch, J. (1985). *A pilot study of Fuzzy set modification of Delphi*. Human System Management, 5(1), 6-80.

Rau, C. S., Yang, J. C. S., Chen, Y. C., Wu, C. J., Lu, T. H., Tzeng, S. L., ... & Hsieh, C. H. (2014). *Lipopolysaccharide-induced microRNA-146a targets CARD10 and regulates angiogenesis in human umbilical vein endothelial cells.* Toxicological Sciences, 140(2), 315-326

Reaves, T. A., Chin, A. C., & Parkos, C. A. (2005). Neutrophil transepithelial migration: role of toll-like receptors in mucosal inflammation. *Memórias do Instituto Oswaldo Cruz*, *100*, 191-198.

Reza, K., & Vassilis, S. M. (1988). Delphi hierarchy process (DHP): A methodology for priority setting derived from the Delphi method and analytical hierarchy process. *European Journal of Operational Research*, *137*, 347-354.

Tang, C. W., & Wu, C. T. (2010). *Obtaining a picture of undergraduate education quality: A voice from inside the university.* Springer Higher Education, 60, 269-286

Ung, S. T., Williams, V., Chen, H. S., Bonsall, S., & Wang, J. (2006). Human error assessment and management in port operations using fuzzy AHP. *Marine Technology Society Journal*, *40*(1), 73-86.

Yusoff, A. F. M., Hashim, A., Muhamad, N., & Hamat, W. N. W. (2021). Application of Fuzzy Delphi technique towards designing and developing the elements for the e-PBM PI-Poli Module. *Asian Journal of University Education*, *17*(1), 292-304.

Zadeh, L. A. (1965). Electrical engineering at the crossroads. *IEEE Transactions on Education*, *8*(2), 30-33.

Zadeh, L. A., Klir, G. J., & Yuan, B. (1996). *Fuzzy sets, fuzzy logic, and fuzzy systems: selected papers* (Vol. 6). World Scientific.

Zaini, Z. H., & Mansor, M. (2019). *Persepsi guru prasekolah kebangsaan terhadap program pembangunan profesional guru.* Southeast Asia Early Childhood Journal, 8(1), 30-36.