JOURNAL OF GOVERNANCE AND INTEGRITY (JGI)
ISSN: 2600-7479 e-ISSN: 2600-786X
VOL. 5, ISSUE 2, 249 – 266
DOI: https://doi.org/10.15282/jgi.5.2.2022.7135

ORIGINAL ARTICLE

DOES EXPERT JUDGEMENT IS IMPORTANT IN MINING INDUSTRY?: A SYSTEMATIC LITERATURE REVIEW

Siti Noraishah Ismail[1,2], Azizan Ramli[1] and Hanida Abd Aziz[1]

[1]Faculty of Industrial Sciences and Technology, College of Computing and Applied Sciences, Universiti Malaysia Pahang, Jalan Tun Abdul Razak, 26300 Gambang, Kuantan, Pahang, Malaysia.
[2]Faculty of Chemical and Process Engineering Technology, College of Engineering Technology, Universiti Malaysia Pahang, Jalan Tun Abdul Razak, 26300 Gambang, Kuantan, Pahang, Malaysia.

ABSTRACT –The Delphi technique is used to achieve consensus from a panel of experts on particular issues by several series or rounds. Previous scholars widely used Delphi in social science studies, business, healthcare, education and many more. However, there is a lack of systematic review on the contribution of Delphi in the engineering and technology field of research. Thus, the aims of this systematic literature review (SLR) are to investigate the contribution of Delphi in solving problems for the past 11 years in the mining industry and to understand the future outlook of Delphi in the Malaysian mining industry. By applying the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), 37 selected papers were identified with three main themes and 24 subthemes created using thematic analysis. Based on the findings, the most highlighted contribution of Delphi came from Theme 3: Delphi's derivatives (50.0%), followed by Theme 1: Mine lifecycle (12.5%), and Theme 2: Analysis of Delphi (37.5 %). In conclusion, an SLR could hopefully increase awareness among mining players to use Delphi in solving their problems which cannot be solved by machinery or tools in achieving a consensus among experts.

ARTICLE HISTORY
Received: 18-11-2021
Revised: 9-12-2021
Accepted: 8-2-2022

KEYWORDS
Delphi technique,
Mining disaster,
Mining industry,
Meta-Analyses,
Systematic literature review

INTRODUCTION

The mining sector is well-known for being a high-risk business with a high chance of accidents. Unfortunately, there are some limitations when it comes to dealing with difficulties that arise at work that cannot be resolved exclusively via the use of technology, advanced equipment, or machines. At this stage, human judgement is required to address the problem. Delphi is a well-known methodology or process for gathering opinions and reaching a consensus among a panel of experts on a topic using quantitative and qualitative methodologies. To avoid near misses, accidents, or disasters in the mining sector, unanimity on certain problems is critical, such as during the planning, development, or production stages of the mining lifecycle. Medicine (Lemmen et al., 2021; Lyu et al., 2020), nursing (Lear, 2020; De Luca et al., 2021), education (Zawacki-richter, 2009), business (El-Gazzar et al., 2016), and psychology (Van der Vaart et al., 2014) have used Delphi techniques to solve problems that require human judgement on specific issues. Despite the fact that Delphi has made substantial contributions to healthcare, education, and business, the applications of this technique in the engineering and technology area are just 6.17% (Flostrand et al., 2020). There is a lack of systematic literature review (SLR) that looks into Delphi's role in engineering and technology, such as in the mining industry. Furthermore, the mining sector was chosen since it is a section of the author's work that makes use of Delphi in the research study (Noraishah et al., 2021). What are the contributions and importance of Delphi in the mining industry? That is the key research issue motivating this systematic study. Therefore, the objectives of the study are to investigate the contribution of Delphi in solving problems for the past 11 years in the mining industry and to understand the future outlook of Delphi in the Malaysian mining industry.

LITERATURE REVIEW

The mining industry is a high-risk occupation and is well known as one of the oldest industries in the world. Mining accidents, mining hazards, mining disasters, or mining catastrophes have similarities which are that they have a great impact on the victims (Lyra, 2019), mine owners (Lyra, 2019; Morisson et al., 2019), mine workers (Li et al., 2019), government (Pons, 2016; Lyra, 2019), policymakers (Liu et al., 2018; Kong et al., 2018; Düzgün & Leveson, 2018), economic loss (Gui et al., 2019; Shao, 2019; Xiao et al., 2019), local community (Zhu et al., 2018; Lyra, 2019) as well as to the environment and human health (Shao, 2019; Francini-filho et al., 2019; Morisson et al., 2019). According to Noraishah et al. (2021), sixteen main causes of mining accidents that occur worldwide can be summarised in Figure 1.

*CORRESPONDING AUTHOR | Azizan Ramli | azizanramli@ump.edu.my

Figure 1. Various main causes of mine accidents (Adapted from Noraishah et al., 2021)

The Delphi method consists of several rounds of written questionnaires that allow experts to give their opinions. After the experts answer each round of questionnaires, the facilitator collects all the answers and hands out a summary report of the answers to each expert. Then, the experts review the summary report and either agree or disagree with the other experts' answers. The experts then fill out another questionnaire that gives them the opportunity to provide updated opinions based on what they understand from the summary report. The Delphi method becomes complete when a consensus of forecasts is achieved. A wide range of opinions can be included, which can be useful in cases where relying on a single expert would lead to bias.

According to Bammer et al. (2013), most research requires only two or three rounds of Delphi. If the goal of the study is to achieve group consensus and the sample is diverse, three or more rounds may be necessary. However, if the goal of the study is to grasp the implications, and the sample size is small, it is possible that fewer than three rounds will suffice to attain consensus, theoretical saturation, or reveal the information needed. The response rate and quality are the bottlenecks. The work required by Delphi participants grows as the number of rounds increases. This often leads to a decrease in response rates (Brady, 2015). Three rounds, according to Custer, Scarcella, and Stewart (1999), are usually adequate to acquire the essential information and attain a consensus. Figure 2 shows the numerous fields of studies that used Delphi techniques as reported by Flostrand et al. (2020). Despite its significant contributions to health care, education, and business, Delphi applications in engineering and technology account for only 6.17% of all Delphi applications (Flostrand et al., 2020). A systematic literature review (SLR) of Delphi's involvement in engineering and technology, such as the mining industry, is lacking as shown in Figure 2.

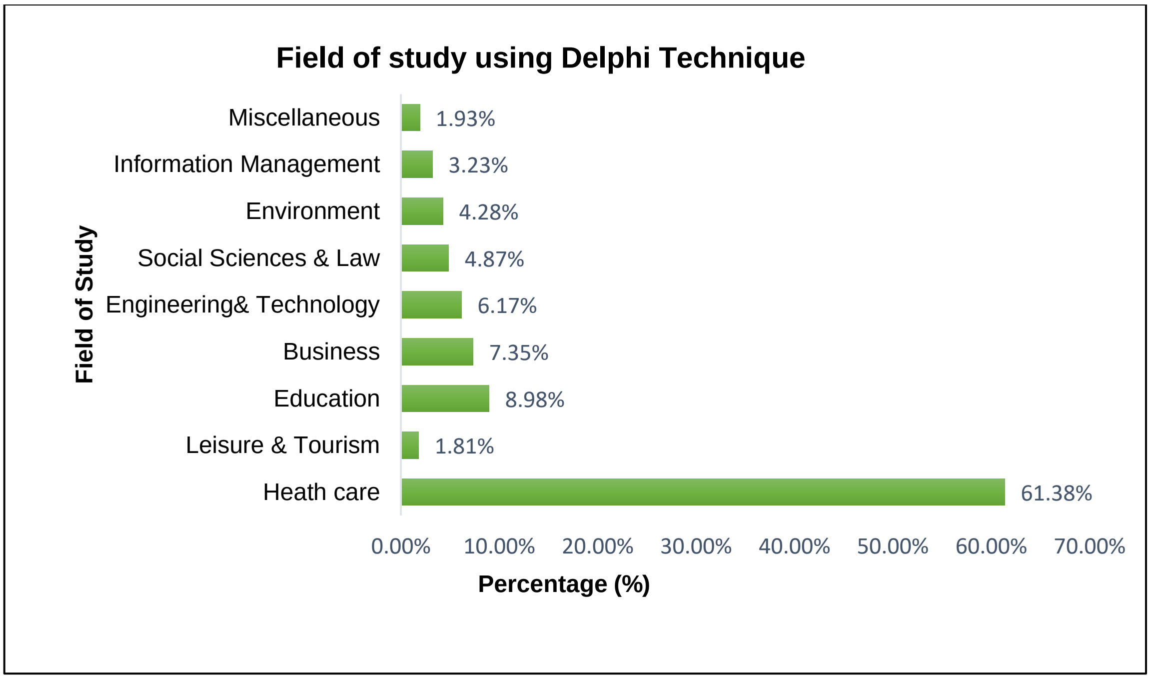

Figure 2. Field of studies that used Delphi Techniques (Adopted from Flostrand et al., 2020)

METHODOLOGY

There are two strategies carried out for this systematic literature review (SLR) which consists of:

i. Data searching: to find related articles using the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) approaches
ii. Analysing the articles based on thematic analysis (Nowell et al.,2017)

For the data or articles for SLR, there are four main steps of PRISMA that consist of (1) identification, (2) screening, (3) eligibility, and (4) data abstraction and analysis. The summary of PRISMA is summarised in Figure 3.

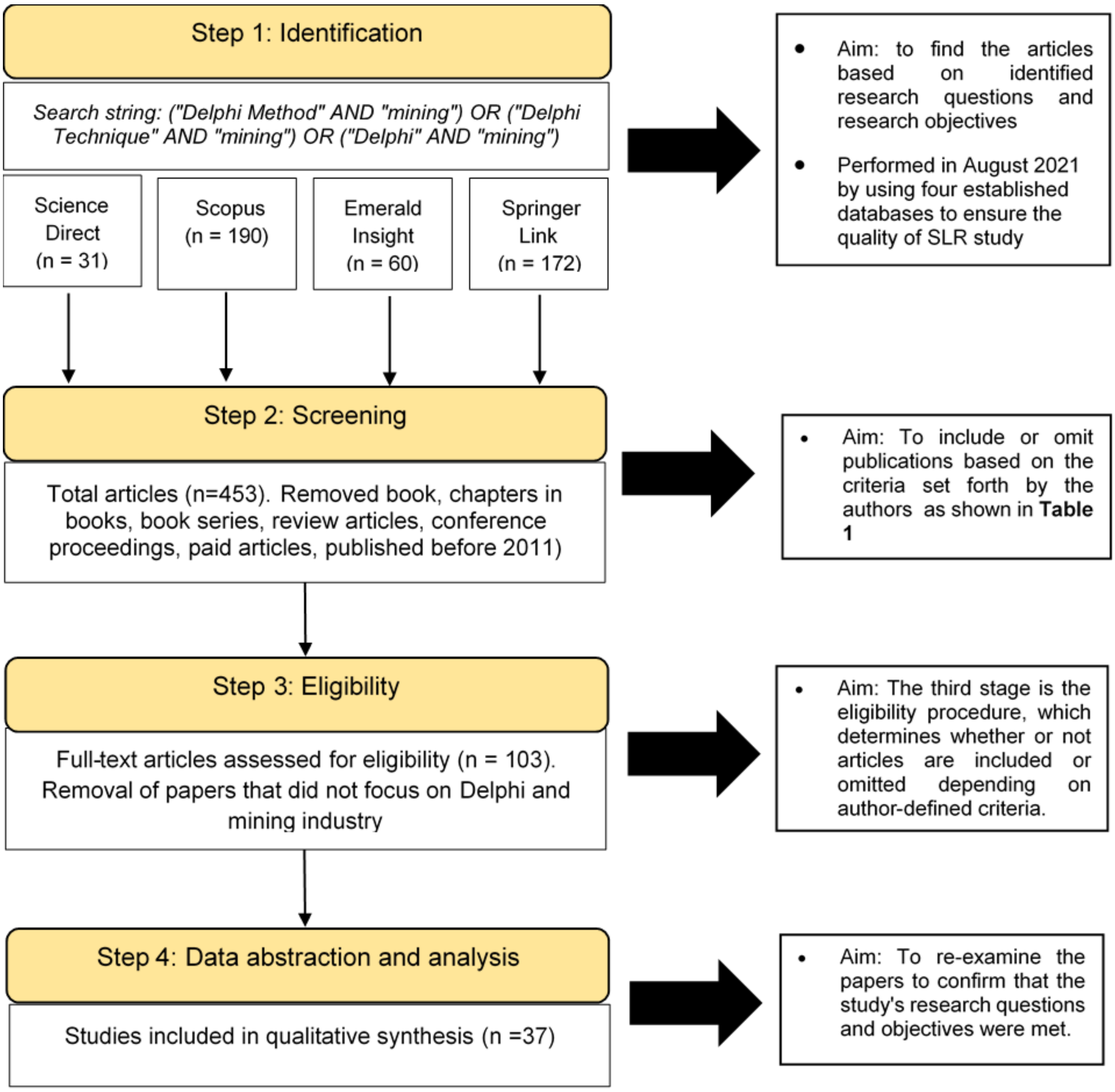

Figure 3. Steps of PRISMA approach used in the SLR study (Modified from Ismail et al., 2021)

Table 1. The inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Publication period	2011-2021	2010 and before
Document type	Journal (research articles) only	Journals (conference proceeding, review paper systematic review, book chapter, and series)
Type of industry	Mining industry only	Exclude other than mining industry, text mining, data mining
Language	English	Non-English

The identification of the themes related to the contribution of Delphi in the mining industry was obtained from Step 4: Data abstraction and analysis where 37 articles were identified and categorised based on thematic analysis. According to Nowell et al., (2017), the thematic analysis consists of six stages as listed below:

1) Data familiarisation (understand and analyse 37 articles)
2) Initial code generation (identify similarities and differences for 37 articles)
3) Theme development (create or identify suitable themes based on 37 articles)
4) Review the constructed themes again (to ensure themes and subthemes lie in the main context of each article)
5) Name the themes and subthemes by defining them and giving them names
6) Report writing (in this case, refers to the SLR)

RESULTS

The findings show the contribution of Delphi based on 37 articles obtained using the PRISMA approach. Fourteen (14) countries consisting of China, Iran, India, Ecuador, Sweden, Canada, Indonesia, Spain, South Africa, Taiwan, Vietnam, Poland, Turkey, and Ghana were highlighted for their contribution to the use of Delphi in solving the problems related to mining operations and activities. The reported number of publications that used Delphi in mining research studies and the respective types of mines based on countries for the year 2011 until 2021 is shown in Table 2. Overall, for the past 11 years, China was the top nation in publishing Delphi articles in the mining industry, with 15 articles, followed by Iran (5 articles), India and Ecuador (3 articles each), Sweden (2 articles), and Canada, Indonesia, Spain, South Africa, Taiwan, Vietnam, Poland, Turkey, and Ghana, each with one article. Table 3 also displayed the SLR findings by year, nation, number of published papers, and journal title.

Table 2. Number of publications that used Delphi in mining research studies with their respective types of mines

Country	Number of publications	Type of Mine
China	15	Coal (12), Phosphate (1), NA (1), various mines (1)
Iran	5	Coal (3), Limestone (1), NA (1)
India	3	Coal (1)
Ecuador	3	Gold (3)
Sweden	2	Coal (2), NA (1)
Canada	1	NA (1)
Indonesia	1	NA (1)
Spain	1	Coal (2)
South Africa	1	Coal (2)
Taiwan	1	NA (1)
Vietnam	1	NA (1)
Poland	1	Coal (1)
Turkey	1	Coal (1)
Ghana	1	Gold (1)

Note: NA is not available or not mentioned in the paper

Table 3. Results of SLR for 37 articles

Year	Country	No of published articles	Title of Journal
2011	China	1	Transactions of Nonferrous Metals Society of China (English Edition)
2012	Not available		
2013	India	1	Journal of Manufacturing Technology Management
2014	Not available		
2015	China	2	Resources Policy
	Turkey	1	Arabian Journal of Geosciences
	Ghana	1	International Journal of Environmental Research and Public Health
2016	China	1	Stochastic Environmental Research and Risk Assessment
	Canada	1	Journal of Cleaner Production
	Sweden	1	International Journal of Mining Science and Technology
2017	Iran	1	International Journal of Coal Science & Technology
		1	Journal of Environmental Health Science & Engineering
	China	1	Safety Science
		1	Environmental Monitoring and Assessment
	South Africa	1	South African Journal of Industrial Engineering
2018	Spain	1	Computers and Industrial Engineering
	Vietnam	1	Environment, Development, and Sustainability
	Iran	1	International Journal Mining & Geo-Engineering
	China	1	Journal of Cleaner Production
		1	PLoS ONE
		1	Occupational and Environmental Medicine
2019	China	1	Geotechnical and Geological Engineering
		2	Hindawi Mathematical Problems in Engineering
	Taiwan	1	Sustainability
	India	1	Clean Technologies and Environmental Policy
2020	India	1	Resources Policy
	Indonesia	1	Indonesian Journal of Electrical Engineering and Computer Science
	Poland	1	Arch. Min. Sci
	Ecuador	1	Resources
	Sweden	1	International Journal of Emergency Services
	China	1	Energies
		1	Natural Resources Research
	Iran	1	Geotechnical and Geological Engineering
		1	International Journal of Quality and Reliability Management
2021	NA	1	Natural Resources Research
	Ecuador	1	Minerals
		1	South African Journal of Industrial Engineering

Three major themes with 24 subthemes were developed using thematic analysis. Figure 3 and Table 4 highlight the number of articles linked to each subtheme, as well as the information for each subtheme. Based on the SLR, 50.0% reported on Theme 3: Delphi's Derivatives, followed by 37.5% on Theme 2: How to Analyse Delphi? and 12.5% on Theme 1: Mine Lifecycle. Based on Figure 3, the most used Delphi was highlighted for the Development of Mine lifecycle (Theme 1) with 22 articles (59.5%), followed by the reclamation stage (n = 7) and Theme 3: Fuzzy Delphi-AHP (n = 7).

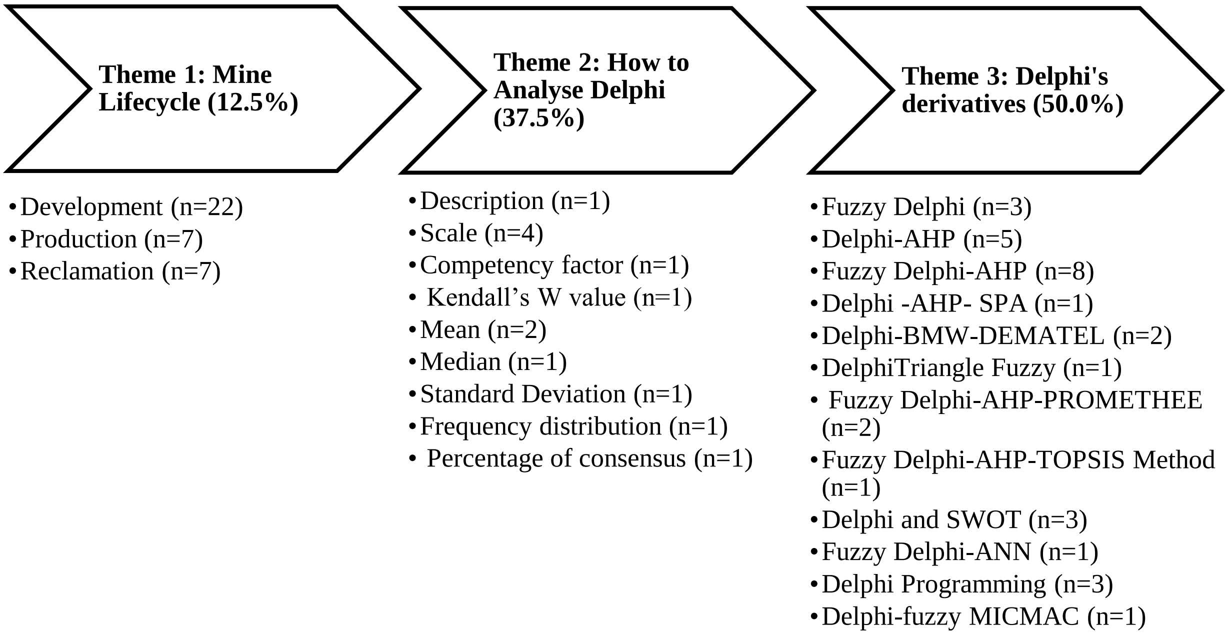

Figure 3. Number of articles related to each subtheme (n) for three themes

Table 4. SLR results on the contribution of Delphi technique/method in mining research from 2011 to 2021 (Theme 1 to Theeme 3

Authors	Country	Type of mine	Theme 1: Mine Lifecycle			Theme 2: How to Analyse Delphi?								
			DEVE	PROD	RECL	DES	SCALE	COMF	KEND	MEAN	MEDIAN	SD	FREQD	PERC
(Wu et al.,2011)	China	Coal			/									
(Barve et al.,2013)	India	Coal			/									
(Shang et al.,2015)	China	Phosphate	/											
(Kavakl et al.,2015)	Turkey	Coal	/											
(Chen et al.,2015)	China	Coal	/											
(Basu et al., 2015)	Ghana	Gold	/											
(Guan et al.,2016)	China	Coal	/											
(DeLoe2016)	Canada	NA		/		/								
(Lanke et al., 2016)	Sweden	NA		/										
(Saffari et al.,2017)	Iran	Coal	/											
(Asghari et al.,2017)	Iran	NA		/									/	
(Chong et al., 2017)	China	Coal mine	/											
(Journal et al.,2017)	South Africa	Coal	/				/							
Geng et al.,2017	China	Coal	/											

Alvarez-Garcia et al.,2018)	Spain	Coal mine	/										
(Yang et al.,2018)	China	Coal	/										
(Anh et al.,2018)	Vietnam	NA	/						/				
(Xu et al.,2018)	China	Coal	/		/								
(Ghadernejad et al.,2018)	Iran	Coal			/								
(Cui et al., 2018)	China	Coal	/						/				
(Sun et al.,2019)	China	Coal	/				/						
(Hsueh et al.,2019)	Taiwan	NA				/							
(Luo et al.,2019)	China	Coal	/										
(Hasanuzzaman et al.,2019)	India	Coal mine			/								
(Nan et al.,2019)	China	NA	/										
(Seam et al.,2020)	China	Coal	/							/			
(Chand et al.,2020)	India	NA	/										
(Setyono et al., 2020)	Indonesia	NA	/										
(Frejowski et al.,2020)	Poland	Coal mine	/					/					
(Sexmo et al.,2020)	Ecuador	Gold				/							
(Gyllencreutz et al.,2020)	Sweden	NA				/				/	/	/	/
(Zhang et al.,2020)	China	coal, iron ore, bauxite, lead–zinc, molyb-denum, gold, fluorite, and graphite	/										
(Mikaeil et al.,2020)	Iran	Coal mine			/								
(Jafarpisheh et al.,2020)	Iran	Limestone		/									
(Li et al.,2021)	China	NA	/										
(Turner et al.,2021)	Ecuador	gold				/	/						
(Herrera-franco et al.,2021)	Ecuador	Gold				/	/						

Authors	Country	Type of mine	Theme 3: Delphi's Derivatives											
			DAHP	FDAHP	DAS	DB	DDT	FFDA	PFA	T.DS	WOT	FD_ANN	DProg	DF-MICMAC
(Wu et al.,2011)	China	Coal		/									/	
(Barve et al.,2013)	India	Coal											/	
(Shang et al.,2015)	China	Phosphate		/										
(Kavakl et al.,2015)	Turkey	Coal											/	
(Chen et al.,2015)	China	Coal												
(Basu et al., 2015)	Ghana	Gold												
(Guan et al.,2016)	China	Coal	/											
(DeLoe2016)	Canada	NA												
(Lanke et al., 2016)	Sweden	NA		/										
(Saffari et al.,2017)	Iran	Coal		/										
(Asghari et al.,2017)	Iran	NA							/					
(Chong et al., 2017)	China	Coal mine			/									
(Journal et al.,2017)	South Africa	Coal												
Geng et al.,2017	China	Coal	/											
Alvarez-Garcia et al.,2018)	Spain	Coal mine												
(Yang et al.,2018)	China	Coal		/										
(Anh et al.,2018)	Vietnam	NA												
(Xu et al.,2018)	China	Coal	/											
(Ghadernejad et al.,2018)	Iran	Coal						/						
(Cui et al., 2018)	China	Coal	/											
(Sun et al.,2019)	China	Coal		/										
(Hsueh et al.,2019)	Taiwan	NA												
(Luo et al.,2019)	China	Coal					/							
(Hasanuzzaman et al.,2019)	India	Coal mine									/			/
(Nan et al.,2019)	China	NA		/										
(Seam et al.,2020)	China	Coal												
(Chand et al.,2020)	India	NA				/								
(Setyono et al., 2020)	Indonesia	NA				/								
(Frejowski et al.,2020)	Poland	Coal mine												
(Sexmo et al.,2020)	Ecuador	Gold									/			
(Gyllencreutz et al.,2020)	Sweden	NA												
(Zhang et al.,2020)	China	coal, iron ore, bauxite, lead–zinc, molyb-	/											

		denum, gold, fluorite, and graphite			
(Mikaeil et al.,2020)	Iran	Coal mine	/		
(Jafarpisheh et al.,2020)	Iran	Limestone		/	
(Li et al.,2021)	China	NA			/
(Turner et al.,2021)	Ecuador	gold			
(Herrera-franco et al.,2021)	Ecuador	Gold			

Theme 1	**Theme 2**	**Theme 3**
DEVE = Development PROD= Production RECL= Reclamation	DES=Description SCALE=Likert's scale COMF= Competency factor KEND= Kendal's value MEAN= Mean MED= Median SD= Standard deviation FREQD= Frequency distribution PERC= Percentage consensus	DF= Fuzzy Delphi DAHP = Delphi-Analytic Hierarchy Process FDAHP = Fuzzy Delphi Analytic Hierarchy Process (AHP) DAS = Delphi Analytic Hierarchy Process- Set Pair Analysis DBD= Delphi- Best Worst Method -Decision-making trial and evaluation laboratory (DEMATEL) DTF = Delphi Triangle Fuzzy FDAP= Fuzzy Delphi- Analytic Hierarchy Process- Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) FAT = Fuzzy- Analytic Hierarchy Process-Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) DSWOT= Delphi and SWOT FD_ANN = Fuzzy Delphi- Artificial Neural Network (ANN) DProg =Delphi Programming Language DFMIMAC= Delphi-fuzzy-Matriced' Impacts Croises-Multiplication Applique' and Classement)

DISCUSSION

The main objective of the SLR was to investigate the contribution of Delphi in the mining industry for the past 11 years. The current review identified 37 studies that showed significant contributions of Delphi. The most highlighted contribution of Delphi came from Theme 3: Delphi's derivatives (50.0%), followed by Theme 1: Mine lifecycle (12.5%) and Theme 2: Analysis of Delphi (37.5%).

Theme 1: Mine lifecycle

The sequence of mine lifecycle starts from the (1) Prospecting, (2) Exploration, (3), Development, (4) Production, and (5) Reclamation stage. Based on the thematic analysis, there are only three stages (or subthemes) involved using Delphi for SLR that consists of exploration, development, and reclamation as subthemes. The biggest contribution of Delphi came from the development stage with 23 studies, followed by the reclamation (8 studies) and production stages (6 studies). For the development stage, out of 23 studies, 16 studies used Delphi for coal mine research studies, and the rest used in phosphate, gold mining, and many more.

Most researchers used Delphi in their studies and claimed Delphi was the most suitable method or technique to find consensus among the experts. This was proven because to open a certain mine, either surface mining or underground mining, the details and critical judgement and point of view of mining experts need to be considered. The extensive experiences of mining experts are vital because mining operations require very detailed planning as well as a great deal of financial investments. Therefore, the previous scholars claimed Delphi was the suitable method to find the consensus among the experts. For example, Xu et al. (2018) in the study on the production of coal mines in China, conducted mine safety assessments to prevent mine accidents by applying the Delphi and set-valued statistics-triangular fuzzy number methods to establish a composite risk analysis model.

For the reclamation stage, Delphi was used in gold, limestone, and coal mines. The reclamation stage refers to the mine closure that requires proper planning before the mine can be closed or abandoned. According to Turner et al. (2021), a combination of the Delphi and Strengths, Weaknesses, Opportunities, and Threats (SWOT) analyses was used to gather opinions from experts to convert the unused mine to a museum site. The importance of Delphi was clear because proper planning for the reclamation stage could prevent the adverse effects of mines to the environment, marine life, and local community as well as to avoid loss of money due to mining accidents or disasters. This kind of contribution by Delphi is significant.

For the production stage, six studies were reported on the usage of Delphi in gold, limestone (Jafarpisheh et al., 2020), and coal mining (Xu et al., 2018; Ghadernejad et al., 2018; Hasanuzzaman et al., 2019) studies. In Delphi, it is important to find a consensus of agreement among the mining team, especially when they face problems at the production stage. The utilisation of machinery in mining is limited when dealing with problems that involve the judgement of humans that cannot be solved by machines or tools. At this point, Delphi was used by previous scholars or researchers when they faced any arising matters at the production stage. The consensus of mining experts was needed to optimise the production, prevent financial loss as well as avoid mining disasters in terms of designing the production layout for mining areas.

Theme 2: Analysis of Delphi

Theme 2: Analysis of Delphi was generated based on 37 studies obtained from the SLR results. Fourteen out of 37 articles discussed how to analyse the Delphi. Based on the SLR articles, there are two types of analysis for the Delphi technique or method as shown in Table 5. Qualitative analysis is more on the description based on the feedback of respondents. This is usually obtained from open-ended interview sessions for the first round of Delphi. For the quantitative analysis, the questionnaire survey will be used, which is in the second round of Delphi. Usually, a 5-point or 7-point Likert scale is used, such as significant to not significant, strongly agree to strongly disagree. The findings will be analysed quantitatively such as mean, median, standard deviation, and many more as shown in Table 5 to achieve the consensus among the panel of experts (respondents).

Table 5. SLR results on Qualitative and Quantitative analysis of Delphi

A. Qualitative analysis	B. Quantitative analysis
i. Description based on interview's findings (DeLoe2016)	i. discussion on Likert's scale (scale significant or not significant or (high to low. (Journal et al.,2017; Sun et al.,2019; Turner et al.,2021; Herrera-franco et al.,2021) ii. Calculate competency factor (Frejowski et al.,2020) iii. Kendall's W value (Anh et al.,2018; Cui et al., 2018) iv. Mean (Seam et al.,2020; Gyllencreutz et al.,2020) v. Median (Gyllencreutz et al.,2020) vi. Standard Deviation (Gyllencreutz et al.,2020) vii. Frequency distribution (Asghari et al.,2017) viii. Percentage consensus (Gyllencreutz et al.,2020)

Furthermore, there are various interpretations to determine the consensus on Delphi. Table 6 shows the determination of expert judgement consensus based on the Delphi Technique (quantitative) as suggested by previous scholars.

Table 6. Determination of Expert Consensus using Delphi Technique (Quantitative)

Delphi's Round	Analysis method	Description to achieve consensus
Quantitative (Interview)	1. Based on statement	Consensus is achieved if (Stitt-Gohdes &Crews, 2004); i. Two-thirds of experts or ii. More than 60% of the experts agreed on each statement known as common consent
	2. Based on percentage response	At least 51% achieve agreement on each response (McKenna, 1994). An increase in percentage agreements for each round (Holey, et al., 2007)
	Analysis method	Description to achieve consensus

		5-point Likert scale	10-point Likert scale
Quantitative (questionnaire survey)	1. Based on Median	According to Lamers et al., (2016); i. Median >3: consensus on agreement with a statement, according to Lamers et al., (2016). ii. Median = 3: there is no consensus on whether or not a statement is true. iii. iMedian 3: agreement on a statement's disagreement.	According to (Aigbavboa et al., 2015); i. Strong consensus: median 9-10, ii. Good consensus: median 7-8.99 iii. Weak consensus: median ≤ 6.99
	2. Based on Standard deviation	Decrease in standard deviations for each round indicates an increase in agreement. (Rayens and Hahn, 2000)	Not available
		Smaller values of standard deviations for each round (Holey, et al., 2007)	Not available
	3. Based on Interquartile Deviation (IQD)	Consensus achieve if IQD of 1.00 or less is obtained (Spinelli,1983) Consensus achieve if Rayens and Hahn (2000) i. IQD of 1.00 for more than 60% of experts answered it with agreement or disagreement ii. More than 60% consensus or agreement.	According to (Aigbavboa et al., 2015); i. Strong consensus - interquartile deviation (IQD) ≤1 and ≥80% (8-10); ii. Good consensus - IQD≥1.1≤2 and ≥60%≤79% (6-7.99); iii. Weak consensus - IQD≥2.1≤3 and ≤ 59% (5.99).

Theme 3: Delphi's Derivatives

For Theme 3, the derivatives of Delphi refer to the combination of Delphi with various multi-criteria decision-making (MCDM) tools in mining research. MCDM is a tool for decision-making. In most decision-making problems, an attempt is made to select the best one according to the requirements and conditions. Based on the SLR, twelve (12) derivatives of Delphi and the objectives for each research have been summarised in Table 7. China was aggressively using the combination of Delphi with various MCDMs to solve their problems in the coal mine, followed by India and Iran as shown in Table 7. The Delphi was used as the basis to find the consensus among the panel of experts and later, for the MCDM tools that will help the researchers to simulate or model it before the real execution takes place at the mine site.

Table 7. SLR Results on Delphi's Derivatives

No	Delphi's Derivatives	Type of Mine/Country	References
1	Fuzzy Delphi	Coal/China	Chen et al.,2015
		Coal/Spain	Alvarez-Garcia et al.,2018
		Not mentioned/ Taiwan	Hsueh et al.,2019
2	Delphi -Analytical Hierarchy Process (AHP)	Coal/China	Guan et al.,2016
		Coal/China	Geng et al.,2017
		Coal/China	Xu et al.,2018
		Coal/China	Cui et al., 2018
		coal, iron ore, bauxite, lead–zinc, molyb- denum, gold, fluorite, and graphite / China	Zhang et al.,2020
3	Fuzzy Delphi -AHP	Coal/China	Wu et al.,2011
		Phosphate/ China	Shang et al.,2015
		Not mentioned	Lanke et al., 2016
		Coal/ Iran	Saffari et al.,2017
		Coal/China	Yang et al.,2018

		Coal/China Not mentioned Coal/ Iran	Sun et al.,2019 Nan et al.,2019 Mikaeil et al.,2020
4	Delphi -AHP- SPA	Coal/China	Chong et al., 2017
5	Delphi-BMW-DEMATEL	Not mentioned/ India Not mentioned/ Indonesia	Chand et al.,2020 Setyono et al., 2020
6	Delphi Triangle Fuzzy	Coal/China	Luo et al.,2019
7	Fuzzy Delphi- AHP-PROMETHEE	Coal/ Iran Limestone/ Iran	Ghadernejad et al.,2018 Jafarpisheh et al.,2020
8	Fuzzy AHP-TOPSIS Method	Not mentioned/Iran	Asghari et al.,2017
9	Delphi and SWOT	Coal/India Gold / Ecuador	Hasanuzzaman et al.,2019 Sexmo et al.,2020
10	Fuzzy Delphi-ANN	Not mentioned/China	Li et al.,2021
11	Delphi-Programming Language	Coal/China	Wu et al.,2011;
12	Delphi-fuzzy- Matriced' Impacts Croises-Multiplication Applique' and Classement (MICMAC)	Coal/India Coal/India	Barve et al.,2013 Hasanuzzaman et al.,2019

Moreover, there are various MCDM tools that have benefits and great potential when combined with Delphi. The flexibility of Delphi which involves qualitative (interview) and quantitative (questionnaire survey) methods can be further refined using MCDM tools which help to achieve accurate supporting findings for the Delphi method before a conclusion on the consensus can be made. For example, Table 8 shows various MCDM models and the application for each of them.

Table 8. Various MCDM models and their applications

No.	MCDM Methods	Applications	References
1	Analytic Network Process (ANP)	i. Agriculture ii. Actuarial iii. Finance iv. Economics v. Energy Management vi. Water Management	(Keyvanfar et al.,2021)
2.	Data envelopment analysis (DEA)	i. Retail and Business ii. Medicine iii. Economics iv. Utilities v. Agriculture vi. Road Safety	(Khoshandam et al., 2014)
3.	Aggregated Indices Randomization method (AIRM)	i. Agriculture ii. Actuarial iii. Finance iv. Economics v. Energy Management vi. Water Management	(Dotsenko et al.,2014)

4.	Weighted Product model (WPM)	i. Distribution Systems ii. Production Planning and Scheduling iii. Portfolio Selection iv. Wildlife Management Health Care v. Energy Planning	(Supriyono et al.,2018)
5	Weighted Sum Model (WSM)	i. Distribution Systems ii. Production Planning and Scheduling iii. Portfolio Selection iv. Wildlife Management Health Care v. Energy Planning.	(Mulliner et al.,2016)
6.	Goal Programming	i. Distribution Systems ii. Production Planning and Scheduling iii. Portfolio Selection iv. Wildlife Management Health Care v. Energy Planning	(Keyvanfar et al.,2021)
7.	ELECTRE (Elimination EtChoix Traduisant la REalite´)	i. Distribution Systems ii. Production Planning and Scheduling iii. Portfolio Selection iv. Wildlife Management Health Care v. Energy Planning	(Komsiyah et al.,2019)
8.	Multi-Attribute Utility Theory (MAUT)	i. Agriculture ii. Actuarial iii. Finance iv. Economics v. Energy Management vi. Water Management	(Kailiponi et al., 2010)
9.	Simple Multi-Attribute Rating Technique (SMART)	i. Transportation and Logistics ii. Assembly Problems. iii. Construction iv. Manufacturing v. Military vi. Environmental	(Barron et al., 1996)
10.	Fuzzy Set Theory	i. Engineering ii. Management iii. Economics iv. Medical v. Social vi. Environmental	(Lin et al.,2021)

FUTURE OUTLOOK FOR MALAYSIAN MINING INDUSTRY

The current study showed no recorded published articles on utilising the Delphi technique in the Malaysian mining industry for the past 11 years using the PRISMA approach from two established journal databases. For example, currently, the research on the mining industry in Malaysia is conducted on ex-tin mining to study the impact on environmental and social activities as reported by Sanusi et al. (2017), Sakai et al. (2017), Ahmed et al. (2018), Sanusi et al. (2021), Shahbudin et al. (2021), and Lehmann et al. (2021). Moreover, Sarman et al. (2019) conducted research on iron ore mining, concentrating on the potential of geotourism for ex-iron ore mines in Bukit Besi, Dungun, Terengganu. Meanwhile, Tohar et al. (2020) studied the potential of major rare earth-bearing minerals in Johor, Malaysia's southern peninsula. Therefore, this is a significant gap whereby the importance of the Delphi Technique, which is to use expert judgement, is not considered in the mining issue or related industrial problems in the Malaysian mining industry. Even though there is no major mining disaster or accidents recorded in the Malaysian mining industry, it does not mean the importance of expert judgement in the mining industry can be denied. The findings could give a valuable lesson to mine players or the government of Malaysia to use expert judgement in solving the current issues or problems at the mining workplace. The role of governance and integrity is also important for government or state authorities in preventing mining accidents. This is related to previous scholars who stressed that a good ethical climate in the organisation, clear policies, guidelines, and code of conduct should be established in all government ministries, departments, and statutory bodies in the public sector (Sajari et al., 2019). The mining business is one of the riskiest industries; thus, expert judgement is important and it must avoid any biased judgement and unethical decisions. Therefore, a good judgement which is closely related to the ability of the expert or leader (AbdulShukor et al., 2019) in practicing world-class business ethics and good governance in solving their problems are crucially required (Wan Husain et al., 2020; Kamarudin et al., 2020; Haron et al., 2020).

LIMITATIONS, IMPLICATIONS, AND RECOMMENDATIONS FOR FUTURE RESEARCH

In mining operations or activities today, the use of technical tools, machinery, or modern equipment is critical. However, the input of humans, particularly their expertise and knowledge in solving problems or difficulties in the sector, is increasingly significant. When assessing a specific issue that cannot be handled by technical techniques, Delphi gives the ultimate agreement or consensus among a panel of specialists. Based on the PRISMA approach, the SLR successfully found 37 publications, and this study has filled the gaps in comprehending Delphi's contribution to the mining sector for the last 11 years (2011 to 2021).

Domains and variables generated from the findings of this study may provide new knowledge for future scholarly efforts. The research also encourages stakeholders in the mining industry to utilise Delphi to tackle problems that cannot be handled using technical solutions. This study makes a number of recommendations for future research, including undertaking systematic reviews of Delphi's contributions to various engineering research projects, such as mechanical, construction, manufacturing, and electrical engineering.

CONCLUSION

The SLR investigated Delphi's contributions to the mining sector in the last 11 years (2011–2021) and used the PRISMA technique to generate three major themes and 24 subthemes utilizing four databases: ScienceDirect, Scopus, Emerald Insight, and SpringerLink. Theme 3: Delphi's derivatives (50.0%) was the most significant Delphi contribution among the 37 papers reviewed, followed by Theme 1: Mine lifecycle (12.5%) and Theme 2: Delphi analysis (37.5%). The SLR determined that expert judgement using Delphi was often used in the development of the mining subtheme under Theme 1. Delphi's participation is critical in planning and designing the mining area for the development stage, with the goal of providing a safe working environment for all mine employees and, as a result, reducing the risk of mining accidents. This study also gives a good understanding of the lack of published scientific articles and the contribution of Delphi in the Malaysian mining industry for the past 11 years. To conclude, expert judgement using Delphi is significant and consensus among experts is required to solve the problem in the mining industry.

REFERENCES

Abdul Shukor, S., & Hussain, S. (2019). Factors Influencing the Effective Leadership Succession Planning: Study on A Malaysian GLC. *KnE Social Sciences*, 3(1), 24–43. https://doi.org/10.18502/kss.v3i22.5106

Ahmed, M. F., Alam, L., Mohamed, C. A. R., Mokhtar, M. Bin, & Ta, G. C. (2018). Health risk of polonium 210 ingestion via drinking water: An experience of Malaysia. *International Journal of Environmental Research and Public Health*, 15(10), 1–19. https://doi.org/10.3390/ijerph15102056

Aigbavboa, C. (2015). A Delphi technique approach of identifying and validating subsidised low-income housing satisfaction indicators. OTMC Conference, 1–10

Alvarez-García, B., & Fernández-Castro, A. S. (2018). A comprehensive approach for the selection of a portfolio of interdependent projects. An application to subsidized projects in Spain. *Computers and Industrial Engineering*, 118(May 2017), 153–159. https://doi.org/10.1016/j.cie.2018.02.025

Asghari, M., Nassiri, P., Monazzam, M. R., Golbabaei, F., & Arabalibeik, H. (2017). Weighting Criteria and Prioritizing of Heat stress indices in surface mining using a Delphi Technique and Fuzzy AHP-TOPSIS Method. *Journal of Environmental Health Science & Engineering*, 1–11. https://doi.org/10.1186/s40201-016-0264-9

Anh, K. (2018). How do local communities adapt to climate changes along heavily damaged coasts ? A Stakeholder Delphi study in Ky Anh (Central Vietnam. Environment, Development and Sustainability, 20(2), 749–767. https://doi.org/10.1007/s10668-017-9908-x

Bammer, G., McDonald, D., & Deane, P. (2013). Research integration using dialogue methods (p. 165). ANU Press

Barve, A., & Muduli, K. (2013). Modelling the challenges of green supply chain management practices in Indian mining industries. *Journal of Manufacturing Technology Management*, 24(8), 1102–1122. https://doi.org/10.1108/JMTM-09-2011-0087

Barron, F. H., & Barrett, B. E. (1996). The efficacy of SMARTER - Simple Multi-Attribute Rating Technique Extended to Ranking. Acta Psychologica, 93(1–3), 23–36. https://doi.org/10.1016/0001-6918(96)00010-8

Basu, A., Phipps, S., Long, R., Essegbey, G., & Basu, N. (2015). Identification of Response Options to Artisanal and Small-Scale Gold Mining (ASGM) in Ghana via the Delphi Process. *International Journal of Environmental Research and Public Health*., 11345–11363. https://doi.org/10.3390/ijerph120911345

Brady, S. R. (2015). Utilizing and Adapting the Delphi Method for Use in Qualitative Research. *International Journal of Qualitative Methods*, 14(5), 160940691562138. https://doi.org/10.1177/1609406915621381

Chand, P., Thakkar, J. J., & Ghosh, K. K. (2020). Analysis of supply chain sustainability with supply chain complexity, inter-relationship study using delphi and interpretive structural modeling for Indian mining and earthmoving machinery industry. *Resources Policy*, 68(February), 101726. https://doi.org/10.1016/j.resourpol.2020.101726

Chen, R. H., Lin, Y., & Tseng, M. L. (2015). Multicriteria analysis of sustainable development indicators in the construction minerals industry in China. *Resources Policy*, 46, 123–133. https://doi.org/10.1016/j.resourpol.2014.10.012

Chong, T., Yi, S., & Heng, C. (2017). Application of set pair analysis method on occupational hazard of coal mining. *Safety Science*, 92, 10–16. https://doi.org/10.1016/j.ssci.2016.09.005

Cui K, Shen F, Han B, et al., (2018). Establishment and application of an index system for prevention of coal workers' pneumoconiosis: a Delphi and analytic hierarchy process study in four state-owned coal enterprises of China.*Occupational and Environmental Medicine*, 75, 654-660

Custer, R. L., Scarcella, J. A., & Stewart, B. R. (1999). The modified Delphi technique: A rotational modification. *Journal of Vocational and Technical Education*, 15(2), 1-10

De Luca, E., Sena, B., Cataldi, S., & Fusillo, F. (2021). A Delphi survey of health education system and interprofessional nurse' role. *Nurse Education Today*, 99(January), 104779. https://doi.org/10.1016/j.nedt.2021.104779

Dotsenko, S., Makshanov, A., & Popovich, T. (2014). Application of Aggregated Indices Randomization Method for Prognosing the Consumer Demand on Features of Mobile Navigation Applications Sergey Dotsenko, Andrey Makshanov, Tatiana Popovich. 8(May), 803–806

Düzgün, H. S., & Leveson, N. (2018). Analysis of soma mine disaster using causal analysis based on systems theory (CAST). *Safety Science*, 110(August), 37–57. https://doi.org/10.1016/j.ssci.2018.07.028

El-Gazzar, R., Hustad, E., Olsen, D.H., (2016). Understanding cloud computing adoption issues: a Delphi study approach. *Journal Systems and Software*, 118, 64–84. https://doi. org/10.1016/J.JSS.2016.04.061

Francini-filho, R. B., Cordeiro, M. C., Omachi, C. Y., Rocha, A. M., Bahiense, L., Garcia, G. D., Tschoeke, D., Almeida, M. G. De, Rangel, T. P., Cherene, B., Oliveira, V. De, Almeida, D. Q. R. De, Menezes, R., Mazzei, E. F., Joyeux, J., Rezende, C. E., Thompson, C. C., & Thompson, F. L. (2019). *Science of the Total Environment*, 697(August), 134038. https://doi.org/10.1016/j.scitotenv.2019.134038

Frejowski, A., & Kabiesz, J. (2020). Criteria for Assessing the Longevity of Hard Coal Mines. 65, 433–452. A*rchives of Mining Sciences*, 65, 3, 433-452. https://doi.org/10.24425/ams.2020.134128

Flostrand, A., Pitt, L., & Bridson, S. (2020). The Delphi technique in forecasting– A 42-year bibliographic analysis (1975–2017). *Technological Forecasting and Social Change*, 150(November 2019), 119773. https://doi.org/10.1016/j.techfore.2019.119773

Geng, H., Chen, F., Wang, Z., Liu, J., & Xu, W. (2017). Environmental management zoning for coal mining in mainland China based on ecological and resources conditions. *Environmental Monitoring and Assessment*, 189(5), 1–9. https://doi.org/10.1007/s10661-017-5932-4

Ghadernejad, S., Jafarpour, A., & Ahmadi, P. (2018). Application of an integrated decision-making approach based on FDAHP and PROMETHEE for selection of optimal coal seam for mechanization ; A case study of the Tazareh coal mine complex , Iran. *International Journal Mining & Geo-Engineering* (IJMGE), Vol. 53, Issue 1 15-23.https://dx.doi.org/10.22059/ijmge.2018.255070.594727

Guan, Y., Shao, C., Gu, Q., Ju, M., & Huang, X. (2016). Study of a comprehensive assessment method of the environmental quality of soil in industrial and mining gathering areas. *Stochastic Environmental Research and Risk Assessment*, 30(1), 91–102. https://doi.org/10.1007/s00477-015-1036-2

Gui Fu, Ziqi Zhao, Chuanbo Hao and Qiang Wu (2019). The Accident Path of Coal Mine Gas Explosion Based on 24Model: A Case Study of the Ruizhiyuan Gas Explosion Accident. *Processes*, 7, 73; https://doi:10.3390/pr7020073

Gyllencreutz, L., Rådestad, M. and Saveman, B.-I. (2020). Templates for handling multi-agency collaboration activities and priorities in mining injury incidents: a Delphi study. *International Journal of Emergency Services*, Vol. 9 No. 3, 257-271. https://doi.org/10.1108/IJES-06-2019-0026

Haron, H., Jamil, N. N., & Ramli, N. M. (2020). Western and Islamic Values and Ethics: Are They Different? J*ournal of Governance and Integrity*, 4(1), 12–28. https://doi.org/10.15282/jgi.4.1.2020.5609

Hasanuzzaman, & Bhar, C. (2019). Development of a framework for sustainable improvement in performance of coal mining operations. Clean Technologies and Environmental Policy, 21(5), 1091–1113. https://doi.org/10.1007/s10098-019-01694-0

Herrera-franco, G., Erazo, K., & Mora-frank, C. (2021). Evaluation of a Paleontological Museum as Geosite and Base for Geotourism . *A Case Study*. 1208–1227.

Holey EA, Feeley JL, Dixon J, Whittaker VJ. (2007). An exploration of the use of simple statistics to measure consensus and stability in Delphi studies. *BMC Medical Research Methodology*, 7:52

Hsueh, S., Sun, Y., & Yan, M. (2019). Conceptualization and Development of a DFuzzy Model for Low-Carbon Ecocities. *Sustainability*. 11, 5833; doi:10.3390/su11205833

Ismail, S. N., Ramli, A., & Aziz, H. A. (2021). Influencing factors on safety culture in mining industry: A systematic literature review approach. *Resources Policy*, 74(May), 102250. https://doi.org/10.1016/j.resourpol.2021.102250

Jafarpisheh, R., Karbasian, M., & Asadpour, M. (2020). A hybrid reliability-centered maintenance approach for mining transportation machines: a real case in Esfahan. *International Journal of Quality and Reliability Management*, 38(7), 1550–1575. https://doi.org/10.1108/IJQRM-09-2020-0309

Journal, S. A., & December, I. E. (2017). Risk Modelling Of Heavy Mobile Equipment To Determine Optimum Replacement. *South African Journal of Industrial Engineering*, Vol. 28(4), 66-79. Doi: http://dx.doi.org/10.7166/28-4-1591

Kavakl, N. (2015). Evaluation of mining investment projects with a new software. *Arabian Journal of Geosciences*, 8(8), 6353–6362. https://doi.org/10.1007/s12517-014-1530-8

Kailiponi, P. (2010). Analyzing evacuation decisions using multi-attribute utility theory (MAUT). *Procedia Engineering*, 3, 163–174. https://doi.org/10.1016/j.proeng.2010.07.016

Kamarudin, D., Zakaria, H., & Azit, A. (2020). Different Ethical Perspectives Justifying Reasonings Behind a Person's Actions: A Case Study on a Private Institution in Malaysia. Journal of Governance and Integrity, 3(2), 9–16. https://doi.org/10.15282/jgi.3.2.2020.5306

Keyvanfar, A., Shafaghat, A., Ismail, N., & Mohamad, S. (2021). Multifunctional retention pond for stormwater management : A decision-support model using Analytical Network Process (ANP) and Global Sensitivity Analysis (GSA). Ecological

Indicators, 124(November 2020), 107317. https://doi.org/10.1016/j.ecolind.2020.107317

Khoshandam, L., Amirteimoori, A., & Matin, R. K. (2014). Marginal rates of substitution in the presence of non-discretionary factors: A data envelopment analysis approach. Measurement: Journal of the International Measurement Confederation, 58, 409–415. https://doi.org/10.1016/j.measurement.2014.09.019

Komsiyah, S., Wongso, R., & Pratiwi, S. W. (2019). Applications of the fuzzy ELECTRE method for decision support systems of cement vendor selection. Procedia Computer Science, 157, 479–488. https://doi.org/10.1016/j.procs.2019.09.003

Kong, D., Liu, S., & Xiang, J. (2018). China Economic Review Political promotion and labor investment efficiency, 273–293. https://doi.org/10.1016/j.chieco.2018.05.002

Lamers, R. E. D., Cuypers, M., Garvelink, M. M., de Vries, M., Bosch, J. L. H. R., & Kil, P. J. M. (2016). Development of a decision aid for the treatment of benign prostatic hyperplasia: A four stage method using a Delphi consensus study. *Patient Education and Counseling*, 99(7), 1249–1256. https://doi.org/10.1016/j.pec.2016.02.004

Lanke, A. A., Hoseinie, S. H., & Ghodrati, B. (2016). Mine production index (MPI)-extension of OEE for bottleneck detection in mining. *International Journal of Mining Science and Technology*, 26(5), 753–760. https://doi.org/https://doi.org/10.1016/j.ijmst.2016.05.050

Lear, H. (2020). Nursing study abroad trip preparation: Finding consensus through a Delphi technique. Nurse Education Today, 90(April), 104443. https://doi.org/10.1016/j.nedt.2020.104443

Lehmann, B. (2021). Formation of tin ore deposits: A reassessment. Lithos, 402–403, 105756. https://doi.org/10.1016/j.lithos.2020.105756Li, D., Koopialipoor, M., & Armaghani, D. J. (2021). A Combination of Fuzzy Delphi Method and ANN-based Models to Investigate Factors of Flyrock Induced by Mine Blasting. *Natural Resources Research*, 30(2), 1905–1924. https://doi.org/10.1007/s11053-020-09794-1

Lemmen, C., Woopen, C., & Stock, S. (2021). Systems medicine 2030: A Delphi study on implementation in the German healthcare system. *Health Policy*, 125(1), 104–114. https://doi.org/10.1016/j.healthpol.2020.11.010

Li, Y., Wu, X., Luo, X., Gao, J., & Yin, W. (2019). Impact of safety attitude on the safety behavior of coal miners in China. *Sustainability* (Switzerland), 11(22). https://doi.org/10.3390/su11226382

Lin, S. S., Shen, S. L., Zhou, A., & Xu, Y. S. (2021). Risk assessment and management of excavation system based on fuzzy set theory and machine learning methods. *Automation in Construction*, 122, 103490. https://doi.org/10.1016/j.autcon.2020.103490

Liu, R., Cheng, W., Yu, Y., & Xu, Q. (2018). International Journal of Industrial Ergonomics Human factors analysis of major coal mine accidents in China based on the HFACS-CM model and AHP method. *International Journal of Industrial Ergonomics*, 68(February), 270–279. https://doi.org/10.1016/j.ergon.2018.08.009

Luo, B., Zhang, J., & Li, Z. (2019). Service Risk Evaluation of the General Contract for Coal Mine Production and Operation : Case Study at Shendong Jinjie Coal Mine in China. *Hindawi Mathematical Problems in Engineering*. Vol. 2019, Article ID 7845756, 12 pages https://doi.org/10.1155/2019/7845756 Research

Lyra, M. G. (2019). The Extractive Industries and Society Challenging extractivism : Activism over the aftermath of the Fundão disaster. *The Extractive Industries and Society*, 6(3), 897–905. https://doi.org/10.1016/j.exis.2019.05.010

Lyu, F., Zheng, C., Wang, H., Nie, C., Ma, X., Xia, X., Zhu, W., Jin, X., Hu, Y., Sun, Y., Zhu, Y., Kuwabara, S., Cortese, R., Maqbool Hassan, K., Takai, K., Paredes, I., Webere, R., Turk, M.,Kimura, J., & Jiang, J. (2020). Establishment of a clinician-led guideline on the diagnosis and treatment of Hirayama disease using a modified Delphi technique. *Clinical Neurophysiology*, 131(6), 1311–1319. https://doi.org/10.1016/j.clinph.2020.02.022

McKenna, H. P. (1994). The Delphi technique: a worthwhile research approach for nursing? *Journal of Advanced Nursing*, 19(6), 1221–1225. https://doi.org/10.1111/j.1365-2648.1994.tb01207.x

Mikaeil, R., Gharahasanlou, E. J., & Jafarpour, A. (2020). Ranking and Evaluating the Coal Seam Mechanization Based on Geological Conditions. *Geotechnical and Geological Engineering*, 38(3), 3307–3329. https://doi.org/10.1007/s10706-020-01200-0

Morisson, C. De, Neumann, R., Ramalho, A., Evangelista, H., Heilbron, M., Cristine, C., Neto, A., Paravidini, G., & Souza, D. (2019). Applied Geochemistry Sm – Nd and Sr isotope fingerprinting of iron mining tailing deposits spilled from the failed SAMARCO Fundão dam 2015 accident at Mariana, SE-Brazil. *Applied Geochemistry*, 106(April), 34–44. https://doi.org/10.1016/j.apgeochem.2019.04.021

Mulliner, E., Malys, N., & Maliene, V. (2016). Comparative analysis of MCDM methods for the assessment of sustainable housing affordability. *Omega* (United Kingdom), 59, 146–156. https://doi.org/10.1016/j.omega.2015.05.013

Nan, J., Liu, C., & Liu, Y. (2019). A Predictive Model of Mining Collapse Extent and Its Application. 2019. Hindawi Advances in Civil Engineering Volume 2019, Article ID 5184287, 10 pages https://doi.org/10.1155/2019/5184287

Noraishah, S., Ramli, A., & Abdul, H. (2021). Research trends in mining accidents study: A systematic literature review. Safety Science, 143(April), 105438. https://doi.org/10.1016/j.ssci.2021.105438

Pons, D. J. (2016). Pike River Mine Disaster:Systems-Engineering and Organisational Contributions. *Safety* 2016, 2, 21; https://doi.org/10.3390/safety2040021

Rayens MK, Hahn EJ. Building consensus using the policy Delphi method. *Policy, Politics, & Nursing Practice*, 1(4):308e15.

Saffari, A., Sereshki, F., Ataei, M., & Ghanbari, K. (2017). Presenting an engineering classification system for coal spontaneous combustion potential. *International Journal of Coal Science & Technology*, 4(2), 110–128. https://doi.org/10.1007/s40789-017-0160-7

Sakai, N., Alsaad, Z., Thuong, N. T., Shiota, K., Yoneda, M., & Ali Mohd, M. (2017). Source profiling of arsenic and heavy metals in the Selangor River basin and their maternal and cord blood levels in Selangor State, Malaysia. *Chemosphere*, 184, 857–865. https://doi.org/10.1016/j.chemosphere.2017.06.070

Sajari, A., Haron, H., & Ismail, I. (2019). Effectiveness of Quality of Chief Integrity Officer. *Ethical Climate*, 3(1), 50–68.

Sanusi, M. S. M., Ramli, A. T., Hashim, S., & Lee, M. H. (2021). Radiological hazard associated with amang processing industry in Peninsular Malaysia and its environmental impacts. *Ecotoxicology and Environmental Safety*, 208, 111727. https://doi.org/10.1016/j.ecoenv.2020.111727

Sanusi, M. S. M., Ramli, A. T., Hassan, W. M. S. W., Lee, M. H., Izham, A., Said, M. N., Wagiran, H., & Heryanshah, A. (2017). Assessment of impact of urbanisation on background radiation exposure and human health risk estimation in Kuala Lumpur, Malaysia. Environment International, 104, 91–101. https://doi.org/10.1016/j.envint.2017.01.009

Sarman, M., Nazer, N. S. M., Desa, K. M., Husin, A., Sulaiman, N., & Huzairy, A. (2019). Anthropogenic geoasset exploration in bukit besi for geotourism development: A preliminary study. Sains Malaysiana, 48(11), 2483–2491.

https://doi.org/10.17576/jsm-2019-4811-18

Seam, T. C. (2020). Study on Intelligent Identification Method of Coal Pillar Stability in Fully Mechanized Caving Face of Thick Coal Seam. *Energies*, 13, 305; doi:10.3390/en13020305

Setyono, R. P., & Sarno, R. (2020). Comparative method of supplier selection in ABC mining company. *Indonesian Journal of Electrical Engineering and Computer Science* 19(2), 890–899. https://doi.org/10.11591/ijeecs.v19.i2.pp890-899

Sexmo, E., Gold, T., Zaruma, M., Loor-oporto, O., & Herrera-franco, G. (2020). Quantitative and Qualitative Assessment of the "El Sexmo" Tourist Gold Mine (Zaruma, Ecuador) as A Geosite and Mining Site. *Resources*, 9, 28; doi:10.3390/resources9030028

Shahbudin, N. R., & Kamal, N. A. (2021). Establishment of material flow analysis (MFA) for heavy metals in a wastewater system. A*in Shams Engineering Journal*, 12(2), 1407–1418. https://doi.org/10.1016/j.asej.2020.10.009

Shang, D., Yin, G., Li, X., Li, Y., Jiang, C., Kang, X., Liu, C., & Zhang, C. (2015). Analysis for Green Mine (phosphate) performance of China: An evaluation index system. *Resources Policy*, 46, 71–84. https://doi.org/10.1016/j.resourpol.2015.08.005

Shao, L., 2019. Geological disaster prevention and control and resource protection in mineral resource exploitation region. February, 142–146. Doi: 10.1093/ijlct/ctz003. I*nternational Journal of Low-Carbon Technologies*, 14, 142–146. doi:10.1093/ ijlct/ctz003. Hindawi Advances in Civil Engineering Volume 2019, Article ID 1269537, 10 pages Doi: 10.1155/2019/1269537.

Spinelli T. The Delphi decision-making process. J Psychol 1983; 113(1):73-80

Stitt-Gohdes, W.L. & Crews, T.B. (2004). The Delphi technique: A research strategy for career and technical education. *Journal of career and technical education*, 20(2):55-67.

Sun, W., & Xue, Y. (2019). An Improved Fuzzy Comprehensive Evaluation System and Application for Risk Assessment of Floor Water Inrush in Deep Mining. *Geotechnical and Geological Engineering*, 37(3), 1135–1145. https://doi.org/10.1007/s10706-018-0673-x

Supriyono, H., & Sari, C. P. (2018). Developing decision support systems using the weighted product method for house selection. AIP Conference Proceedings, 1977(June 2018). https://doi.org/10.1063/1.5042905

Tohar, S. Z., & Yunus, M. Y. M. (2020). Mineralogy and BCR sequential leaching of ion-adsorption type REE: A novelty study at Johor, Malaysia. *Physics and Chemistry of the Earth*, 120, 102947. https://doi.org/10.1016/j.pce.2020.102947

Turner-Carrión, M.; Carrión-Mero, P.; Turner-Salamea, I.; Morante-Carballo, F.; Aguilar-Aguilar, M.; Zambrano-Ruiz, K.; Berrezueta, E. A Mineralogical Museum as a Geotourism Attraction: A Case Study. *Minerals*, 11, 582. https://doi.org/10.3390/min11060582

Van der Vaart, R., Witting, M., Riper, H., Kooistra, L., Bohlmeijer, E.T., Van Gemert- Pijnen, L.J., 2014. Blending online therapy into regular face-to-face therapy for depression: content, ratio and preconditions according to patients and therapists using a Delphi study. *BMC Psychiatry* 14 (1), 355. https://doi.org/10.1186/s12888- 014-0355-z

Wan Husain, W. A. F. (2020). Insights: the Conceptual Framework for Buiding the World Class Good Governance Ethics. *Journal of Governance and Integrity*, 4(1), 1–5. https://doi.org/10.15282/jgi.4.1.2020.5606

Wu, X. Q., Zuo, X. Q., & Fang, Y. M. (2011). Evaluation of reclamation land productivity in mining districts. *Transactions of Nonferrous Metals Society of China* (English Edition), 21(SUPPL. 3), s717–s722. https://doi.org/10.1016/S1003-6326(12)61668-9

Xiao, W., Xu, J., & Lv, X. (2019). Establishing a georeferenced spatio-temporal database for Chinese coal mining accidents between 2000 and 2015. *Geomatics, Natural Hazards and Risk*, 10(1), 242–270. https://doi.org/10.1080/19475705.2018.1521476

Xu Q, Xu K (2018) Mine safety assessment using gray relational analysis and bow tie model. *PLoS ONE*, 13(3): e0193576. https://doi.org/10.1371/journal.pone.0193576

Yang, Z., Li, W., Pei, Y., Qiao, W., & Wu, Y. (2018). Classification of the type of eco-geological environment of a coal mine district: A case study of an ecologically fragile region in Western China. *Journal of Cleaner Production*, 174, 1513–1526. https://doi.org/10.1016/j.jclepro.2017.11.049

Zawacki-Richter, O., 2009. Research areas in distance education: a Delphi study. *The International Review of Research in Open and Distributed Learning*, 10 (3). https:// doi.org/10.19173/irrodl.v10i3.674.

Zhang, Y., Li, X., Wang, S., Guo, J., & Lv, G. (2020). A Multi-objective Zoning Framework for Mineral Resources Development and Management: A Case Study in Henan Province, China. *Natural Resources Research*, 29(5), 3103–3119. https://doi.org/10.1007/s11053-020-09652-0

Zhu, W., Yao, N., & Yan, J. (2018). International Journal of Disaster Risk Reduction Exploring the determinants of disaster coverage: Evidence from coal mine disasters coverage in China. *International Journal of Disaster Risk Reduction*, 31(August), 856–861. https://doi.org/10.1016/j.ijdrr.2018.08.002

AUTHORS' BIOGRAPHY

Author's Full Name: Ts. Dr. Azizan Ramli
Author's Email: azizanramli@ump.edu.my
Author Professional Bio: Ts. Dr. Azizan Ramli is a senior lecturer at Faculty of Industrial Sciences & Technology, Universiti Malaysia Pahang, Malaysia where he teaches process safety, occupational safety, health & environment and process engineering management. He holds a PhD in technological hazards, Universiti Kebangsaan Malaysia. He has more than 10 years' working experience as an engineer before joining UMP in 2008. He is a registered Professional Technologist, Malaysia Board of Technologists (MBOT), graduate member of the Institution of Engineers, Malaysia (IEM), professional member of the International Institute of Risk Management and Crisis Strategies (IIRMACS), and member of Malaysian Society for Occupational Safety and Health (MSOSH). His research interest is process safety, especially with respect to issues relating to industrial disaster risk reduction. He has authored and co-authored several books and academic articles on the topics with regards to safety

Author's Full Name: Siti Noraishah Ismail
Author's Email: snoraishah@ump.edu.my
Author Professional Bio: Siti Noraishah Ismail is a lecturer in Faculty of Chemical and Process Engineering Technology, Universiti Malaysia Pahang (UMP). She graduated her Master degrees at UMP majoring in MSc Mining with Mineral Technology and MSc Petroleum Engineering at Universiti Teknologi Malaysia (UTM). She completed her undergraduate in B.Eng Chemical (Gas Engineering) in UTM. Currently she is pursuing her PhD in Occupational Safety and Health in UMP.

Author's Full Name: Ts. Dr. Hanida Abdul Aziz
Author's Email: hanidaaziz@ump.edu.my
Author Professional Bio: Ts. Dr. Hanida Abdul Aziz is a senior lecturer at Faculty of Industrial Sciences and Technology, Universiti Malasysia Pahang. Her areas of research expertise include PSM system and risk management. She is a principal investigator of FRGS and ASEAN NCAP research projects. She also has published articles in reputable journals including Chemical Engineering Bulletin and Process Safety Progress.