DEVELOPING A SAFETY CULTURE FRAMEWORK FOR THE MINING INDUSTRY IN MALAYSIA

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ABSTRAK

Bencana lombong membawa kepada kematian serta kesan buruk kepada ekonomi kita. Pada masa kini, budaya keselamatan adalah penting sebagai cara untuk mencegah kemalangan atau bencana perlombongan. Tiga dimensi utama diperlukan untuk membina budaya keselamatan yang baik: dimensi psikologi, situasi dan tingkah laku. Selain itu, faktor yang mempengaruhi bagi setiap dimensi adalah penting untuk disiasat dan difahami bagi industri perlombongan. Malaysia telah dikurniakan pelbagai mineral, seperti emas, bijih timah, bauksit, dan bijih besi. Nasib baik, sehingga kini, tiada bencana perlombongan berskala besar berlaku di Malaysia. Walau bagaimanapun, kekurangan kajian mengenai budaya keselamatan dalam industri perlombongan Malaysia telah dibincangkan. Menurut Pertubuhan Keselamatan Sosial Malaysia, terdapat 130,000 pekerja lombong pada tahun 2021 di Malaysia, dengan peningkatan kemalangan perlombongan dilaporkan. Oleh itu, objektif kajian ini adalah untuk menyiasat faktor-faktor yang mempengaruhi budaya keselamatan psikologi, situasi dan tingkah laku dan membangunkan rangka kerja budaya keselamatan untuk industri perlombongan Malaysia. Kajian ini menggunakan kaedah campuran berjujukan penerokaan. Kajian ini dimulakan dengan kajian awal yang melibatkan tinjauan literatur yang luas yang dipanggil (i) Kajian Literatur Sistematik dan (ii) sesi temu bual dengan pakar perlombongan sukarela. Berdasarkan sesi temu bual, semua pakar bersetuju bahawa kesedaran dan amalan budaya keselamatan di Malaysia masih rendah (kurang daripada 50% untuk perlombongan berskala kecil) dan boleh mencapai sehingga 70% untuk perlombongan berskala besar. Jurang ini perlu ditutup, dan rangka kerja budaya keselamatan menuntut Malaysia. Kajian diteruskan dengan Delphi I dan Delphi II, dengan penglibatan 21 dan 18 pakar perlombongan masing-masing sebagai responden. Responden ini terdiri daripada perunding perlombongan, penguatkuasa kerajaan, pemilik lombong, pengurus perlombongan, ahli akademik, The Delphi I bermula dengan sesi temu duga terbuka, yang dijalankan melalui Google Meet dari Mac hingga Mei 2021. Objektif sesi temu duga adalah untuk menyiasat faktor-faktor yang mempengaruhi budaya keselamatan psikologi, situasi dan tingkah laku dalam kalangan 21 pakar perlombongan. Kesemua dapatan kualitatif dianalisis menggunakan analisis tematik. Terdapat 5, 10, dan 9 faktor pengaruh penting yang diperolehi untuk dimensi psikologi, situasi dan tingkah laku. Bagi Delphi II, tinjauan soal selidik budaya keselamatan telah disahkan oleh pengesah dan diedarkan kepada pakar perlombongan. Berdasarkan Delphi II, konsensus yang kukuh telah dicapai, menghasilkan 64.81%, 73.15%, dan 73.55% masing-masing untuk dimensi psikologi, situasi dan tingkah laku, dalam kalangan pakar perlombongan. Proses Hierarki Analitik (AHP) digunakan untuk mengutamakan semua faktor ini dan telah disahkan oleh pakar dalam perbincangan Kumpulan Fokus dan kajian kes yang dijalankan di Syarikat Perlombongan X sukarela di Pahang. Akhir sekali, rangka kerja budaya keselamatan yang disahkan terdiri daripada dimensi psikologi (5 faktor), situasi (10 faktor), dan tingkah laku (9 faktor). Sikap Keselamatan, (ii) Kepimpinan, (iii) Penguatkuasaan Peraturan Keselamatan, (iv) Kesedaran Keselamatan, serta (v) Ganjaran dan Hukuman telah diiktiraf sebagai lima faktor kritikal bagi rangka kerja budaya keselamatan dalam industri perlombongan di Malaysia. Kesimpulannya, rangka kerja budaya keselamatan diharap dapat memberi manfaat kepada industri perlombongan dan menjadi salah satu penyelesaian untuk mencegah kemalangan lombong di Malaysia.

ABSTRACT

Mine disasters lead to fatalities as well as detrimental effects on our economy. These days, safety culture is important as a means of preventing mining accidents or disasters. Three main dimensions are required to construct a good safety culture: psychological, situational, and behavioral dimensions. Moreover, the influencing factors for each dimension are critical to be investigated and understood for the mining industry. Malaysia has been blessed with various minerals, such as gold, tin ore, bauxite, and iron ore. Fortunately, to date, no large-scale mining disaster has occurred in Malaysia. However, a lack of study on the safety culture in the Malaysian mining industry was discussed. According to the Malaysian Social Security Organization, there were 130,000 mine workers in the year 2021 in Malaysia, with increasing mining accidents reported. Therefore, the objectives of this study were to investigate the influencing factors of psychological, situational, and behavioral safety culture and develop a safety culture framework for the Malaysian mining industry. This study applied an exploratory sequential mixed method. The study started with a preliminary study that involved an extensive literature review called (i) Systematic Literature Review and (ii) interview sessions with volunteered mining experts. Based on the interview session, all experts agreed that safety culture awareness and practices in Malaysia are still low (less than 50% for small-scale mining) and can reach up to 70% for large-scale mining. This gap needs to be closed, and the safety culture framework is demanding for Malaysia. The study was continued with Delphi I and Delphi II, with the involvement of 21 and 18 mining experts as respondents, respectively. These respondents consisted of mining consultants, government enforcers, mine owners, mining managers, academicians, The Delphi I started with the open-ended interview session, which was conducted via Google Meet from March to May 2021. The objective of the interview session was to investigate the influencing factors of psychological, situational, and behavioral safety culture among 21 mining experts. All the qualitative findings were analyzed using thematic analysis. There are 5, 10, and 9 important influencing factors obtained for the psychological, situational, and behavioral dimensions. For Delphi II a safety culture questionnaire survey was validated by a validator and distributed to the mining experts. Based on Delphi II, a strong consensus was reached, resulting in 64.81%, 73.15%, and 73.55% for the psychological, situational, and behavioral dimensions respectively, among the mining experts. The Analytical Hierarchy Process (AHP) was used to prioritize all these factors and were validated by experts in Focus Group discussions and a case study conducted at a volunteered Mining Company X in Pahang. Finally, the validated safety culture framework consists of psychological (5 factors), situational (10 factors), and behavioral (9 factors) dimensions. Safety Attitude, (ii) Leadership, (iii) Enforcement on Safety Rules, (iv) Safety Awareness, as well as (v) Reward and Punishment were recognized as the top five of critical factors for safety culture framework in mining industry in Malaysia. In conclusion, it is hoped that the safety culture framework can benefit the mining industry and become one of the solutions for preventing mine accidents in Malaysia.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

μ	Median
$\bar{x}$	Mean
σ	Standard deviation
α	Cronbach Alpha
A	Determinant of matrix
a_{ij}	Element of matrix
w_{max}	Largest Eigenvalue
w	Weight vector
λ	Eigenvalue or fundamental value
n	The number of criteria to be compared
A	Determinant of matrix
a_{ij}	Element of matrix
R	Number of items
σ_1^2	Variant items
σ_x^2	Total score variant
$\sum$	Sum of

LIST OF ABBREVIATIONS

AHP	Analytical Hierarchy Process
CR	Consistency Ratio
CI	Consistency Index
DOSH	Department of Occupational Safety and Health
FGD	Focus Group Discussion
IAEA	International Atomic Energy Agency
JMG	Jabatan Mineral dan Galian
MCDM	Multiple criteria decisions making
OSH	Occupational Safety and Health
OSHE	Occupational Safety, Health, and Environment
OSHWA	Occupational Safety and Health Work Assessment
RI	Random Index
SDG	Sustainable Development Goals
SLR	Systematic Literature Review
SOCSO	Social Security Organization of Malaysia

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Research Background

The concept of safety culture has received attention from various industries around the world as a solution to minimise the potential for large-scale disasters and accidents (Cooper, 2000). Safety culture focuses on the root causes of accidents, not the symptoms of accidents, leading to a more effective accident prevention strategy (Jiang, Fu, Liang, Yang and Han, 2020). To support these statements, many researchers have shifted conventional accident prevention towards promoting a healthy safety culture in organisations (Stemn, Ntsiful, Azadah, and Joe-Asare, 2020; Jiang, Liang, and Han, 2019; Lööw and Nygren, 2019). One of the strategies is to understand the safety attitude among miners towards safety culture. For example, poor physiological status and bad safety habits were examples of safety attitudes among 27 coal mining enterprises, as reported by Jiang et al. (2019). One of the difficulties in implementing a safety culture was the ignorance of safety among miners (Lööw and Nygren, 2019). To promote a good safety culture, safety knowledge must be strengthened first, such as knowledge on production and production equipment, machine handling, safety awareness, knowledge on skills and competencies, and training on self-protection (Miao Lin, Duan, Meng, Sun, Xiu, Wu, and Yu, 2020; Zhang, Li, Wang, Guo, and Lv, 2020; Wang and Wu, 2019). Moreover, to foster a safety culture, it is important for mine owners to provide a safer working environment to mine workers (Jiang et al., 2020; Rubin, Giacomini, Allen, Turner, and Kelly, 2020).

Working conditions in the mining sector often pose significant dangers, with the potential for simultaneous fatalities from events like fire, flood, explosion, collapse, or other disasters. Despite the risks, the mining industry plays a vital role in supplying raw materials, minerals, and metals crucial to the economy. The global mining sector is expanding at a rate of approximately 3.3 billion metric tonnes per year (Anonymous, 2007). For example, China boasts the world’s largest coal mining sector, producing up to

3 billion metric tonnes annually. Although the nation produces 40% of the world's coal, it is also the cause of 80% of mining-related fatalities worldwide each year (Olivia, 2010). In historical context, China holds the record for the greatest number of deaths in a single mining accident, with 1,572 casualties in an accident at the Honkeiko coal mine on April 26, 1942 (Anonymous, 2007). Furthermore, one of the latest mining accidents occurred in the Amasra coal mine in Amasra, Bartn Province, where Turkey experienced an explosion on October 14, 2022, which killed 42 people and injured 27 others. It was among Turkey's deadliest industrial accidents (Merlyn and Elsa, 2022).

Mining has a rich history in Malaysia, dating back to the 1820s. In 2021, there are 131,000 mine workers in Malaysia (SOCSO Annual Report, 2021). This workforce is relatively modest when compared to other industries like construction and manufacturing in Malaysia. To the best of the researcher's knowledge, Malaysia has not experienced significant mining disasters resulting in a high number of fatalities, unlike some other countries. Table 1.1 shows the mining accidents in Malaysia as reported by employees (Department of Occupational Safety and Health [DOSH], 2024). For example, four people died and at least 30 others were injured in a coal mine explosion at Selantik coal mine in Sarawak, Malaysia, on November 22, 2022 (Sharon, 2022). Such accidents can be averted when the safety of mine workers is the top priority of the mine operators or mine owners. All these accidents can be prevented by promoting a good safety culture at mine workplace.

Table 1.1 Example of Mining accidents in Malaysia

Date	Type of Mine (State)	Summary Case	Major concern
10/10/2015	Iron Ore Mine, Pahang	The accident happened when the victim, driving down a hill with a shovel, lost control of the vehicle. It went over the edge of a 15-foot cliff, and the victim became trapped inside the cabin	Lack of safety rules and precautions.
22/11/2014	Coal mine in Selantik , Sarawak	4 people died and 30 were injured in a mine rock explosion at a coal mine.	Lack of trust in the company's supervisors and engineers due to potential issues with switch insulation inside the mine.

Table 1.1 Continued

Date	Type of Mine (State)	Summary Case	Major concern
20/12/2014	Iron Ore Mine, Pahang	Died due to mine cave-in.	Lack of safety precaution
24/2/2021	Mining, Selangor	A worker drowned in a mining lake after the fibreglass boat he was riding in got into the water and sank	Lack of safety aspects such as no registration at work, no dredger-related information was provided, lack of safety instruction, standard of procedure
5/4/2023	Mining, Perak	Worker crushed by a shovel machine.	Lack of safety instruction, standard of procedure
29/1/2024	Mining area in Kedah	Worker died due to a rock and soil collapse	Poor working environment

Source: Department of Occupational Safety and Health (2024)

Since Malaysia is blessed with various minerals such as gold, tin, rare earth, and many more, safeguarding our minerals is crucial to prevent mining accidents, which can lead to economic, human, and environmental losses. Numerous scholars have suggested the importance of fostering safety culture practices in the mining industry. This not only helps prevent mining accidents or disasters, but also educates mine workers to be responsible miners (Jiang et al., 2020; Nikulin and Nikulina, 2017). In Malaysia, laws and regulations such as the Occupational Safety and Health Act 1994 (OSHA) have been enacted by the government to protect the rights and benefits of workers in the mining industry. Moreover, the Factory and Machinery Act of 1967 (FMA) served to ensure that both employers and employees take the initiative in reducing industrial hazards (Hee, 2014). Figure 1.1 shows the latest legislative related to safety culture in the Malaysian mining industry.

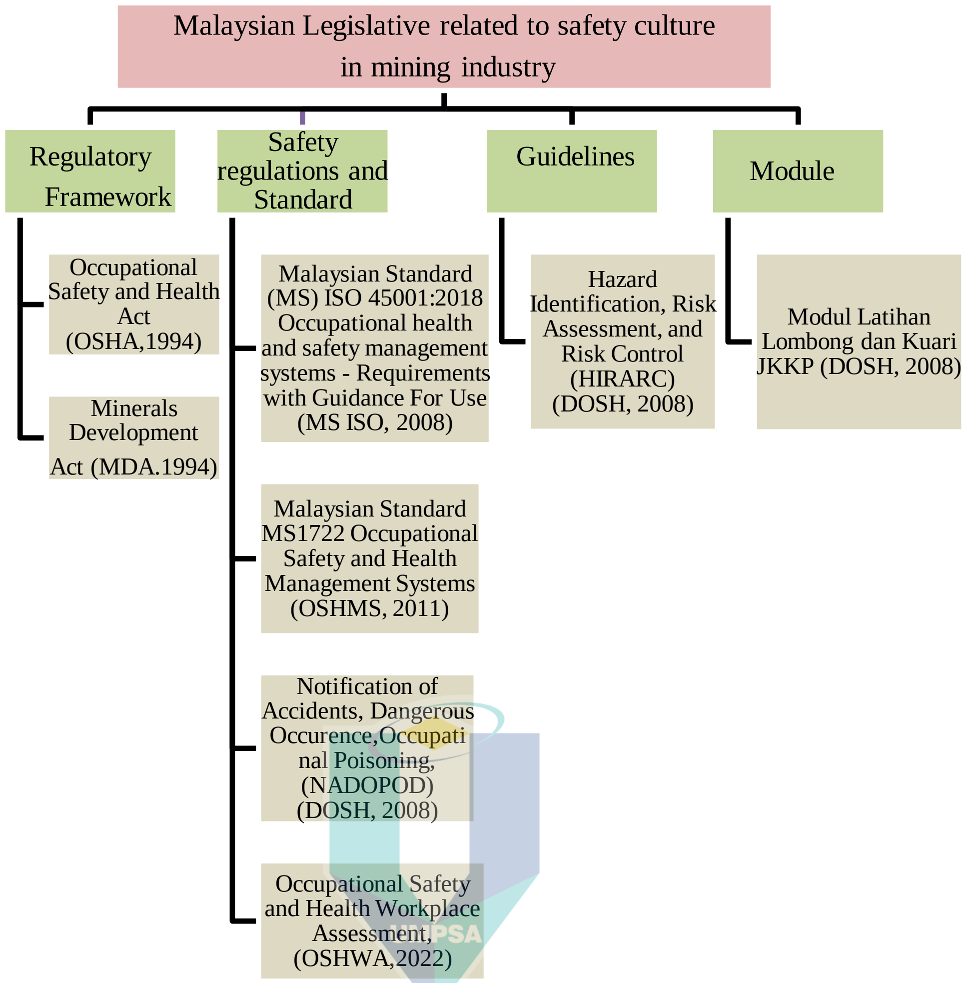


Figure 1.1 Legislative related to development of safety culture in the Malaysian mining industry

Source: OSHA (1994), MDA (1994), MS ISO (2018), OSHMS (2011), DOSH (2008), OSHWA (2022)

The Social Security Organization of Malaysia (SOCSO) receives more than 100,000 claims every year for industrial and commuting accidents, and there were 82,361 accidents involving workers reported to SOCSO in 2022. On average, the number of mining accidents reported in Malaysia was 300 per year for the past 10 years (Social Security Organization of Malaysia [SOCSO], 2021). To address this issue, SOCSO has introduced Vision Zero, a strategic initiative aimed at preventing workplace accidents, including promoting the health and wellbeing of employee (DOSH, 2020). The philosophy of Vision Zero posits that all occupational accidents, injuries, and diseases are preventable. It promotes a culture of prevention where everyone, not only employees and employers, rejects the acceptance of accidents. The emphasis lies on the proactive avoidance of accidents and emphasizing their preventability. Moreover, if accidents can be prevented, it will have a positive impact on workers, ensuring stable earnings. It will ensure that families have breadwinners they can depend on, guarantee employers' human capital, and ensure the nation's productivity and economic stability.

Moreover, the Malaysian government has exhibited a proactive approach to minimise workplace accidents through the implementation of a strategic plan known as the Occupational Safety and Health Master Plan (OSHMP 15) under the Department of Occupational Safety and Health (DOSH). This strategic plan is designed to enhance workers' safety attitudes and foster a safer working environment in Malaysia (DOSH, 2020). Unfolding across three stages over 15 years from 2005 to 2020, it takes place as follows: The initial five years, the government would emphasise promoting safety and health ownership at the workplace; from 2010 to 2015, self-regulation was believed to have been achieved; and in the last five years, preventive culture would have been implanted in the workplace (Farouk, Richardson, and Santhapparaj, 2011).

In brief, through OSHMP 15, the government has endeavoured to nurture and maintain a positive safety culture and reduce accident rates in working environments (Masilamani, 2010). Moreover, the vision of the Occupational Safety and Health Master Plan 2020 (OSHMP 2020) envisions inculcating a safe and healthy work culture for the well-being of workers, employers, and the country (DOSH, 2020). Reflecting on the strategic planning of OSH-MP2020 and Vision Zero, both dedicated to instilling a positive safety culture in the workplace; it appears plausible for the mining industry to attain a zero-accident status. Given the relatively small number of mine workers, effective coordination becomes feasible with full commitment from mine owners and workers, coupled with proper dissemination of safety culture knowledge among them. Currently, a Plan Framework Transformation 2021-2030 Industry Minerals of Malaysia (TIM 2021-2030) was launched by Ministry of Energy and Natural Resources (KeTSA) to drive this industry responsibly and sustainably.

Various safety culture models exist today, including the Bandura Reciprocal Determinism Model (Bandura, 1986), Schein's Theory (Schein et al., 1992), Geller's Theory (Geller, 1994; Geller, 1997), Reason Safety Culture Model (Reason et al., 1997), Guldenmund's Three Layered Organisational Culture (Guldenmund, 2000), and the Reciprocal Safety Culture Model by Cooper (Cooper, 2000). These models primarily centre around constructing a safety culture through three key dimensions. To illustrate, the Cooper Model (Cooper, 2000) emphasises psychological, situational, and behavioural dimensions in cultivating a good safety culture.

According to Hu, Rahmandad, Smith-Jackson, and Winchester (2011), safety attitude is the psychological perspective towards safe practices, policies, and accident prevention under the psychological dimension. The Cooper Model refers to psychological dimension as *"what people feel/ care"*. It is important to have a good psychological environment for both employers and employees to work together towards practicing a safety culture at my workplace. The Cooper Model also stresses *"what the organization has"* for the situational dimension (Cooper, 2000). Lack of safety at the workplace and a poor physical work environment are examples of situational dimensions in the safety culture (Lööw and Nygren, 2019). In addition, insufficient personal safety equipment and ventilation problems (Düzgün and Leveson, 2018) are also examples of poor situational dimensions. These problems can be prevented by raising awareness among mine owners or operators by prioritising safety practices at the mine workplace, and it is hoped that this will reduce mining accidents in the future. For the behavioural dimension, it focuses on *"what people do,"* according to Cooper (2000). Zhang, Fu, and Hao (2020) contend that a poor safety culture is a reflection of management's commitment in this issue. A strong ability to lead and coordinate is also a crucial component of management's commitment to building a positive safety culture (Düzgün et al., 2018).

Since there is a lack of study on the influencing factors of safety culture in the Malaysian mining industry, it is an opportunity to penetrate the existing practices of safety culture among mine workers and build a safety culture framework that is useful to the mining industry in Malaysia. Therefore, the main objectives of the study are to investigate the influencing factors on safety culture in psychological, situational, and behavioural dimensions and to develop a safety culture framework for the Malaysian mining industry.

1.2 Problem Statement

Three main research problems which drove the safety culture study are as listed below:

1) The influencing factors of the psychological dimension are important to creating a safety culture framework for the Malaysian mining industry.

According to Malaysia Big Data Analytics: National Occupational Accident and Disease for Statistics Report in Year 2021 (Department of Statistics Malaysia [DOSM], mining and quarrying are the most high-risk sectors for fatal occupational injuries, with a rate of 10.98 per 100,000 workers in 2021. Therefore, accident prevention at the mine site by creating a safe workplace and a responsible mine worker is important. To create it, the influencing factors of the psychological dimension are important to be investigated for the Malaysian mining industry.

Responsible miners reflect the good safety attitude of the mine workers themselves (Jiang et al., 2000). This is one of the main factors in the psychological dimension (Jiang et al., 2000). Mine workers may have limited knowledge of safety culture because "culture" cannot be explicitly explained (Guldenmund, 2000; Weigmann, Zhang, Von Thaden, and Sharma, 2004; Wu, Yin, Wu, and Li, 2017). Thus, it is highly possible that mine workers do not know the correct ways to implement a safety culture at the workplace (Wang, Wang, and Qi, 2016). By increasing the level of safety culture knowledge, mine owners and mine employees are more likely to demonstrate positive attitudes towards safety (Yurio, Haas, Bell, Moore, and Greenwald, 2020).

Furthermore, previous scholars suggested that the psychological dimension also required the commitment and concern of top management for their workers. Lack of attention from top management or employers led to job satisfaction among mine workers (Ajith, Gosh, and Jansz, 2020). This can cause the productivity of workers to decrease, and the workers tend to break the rules and regulations while performing the job (Quansah, Yongyue, and Minyu, 2023). Therefore, a solid understanding of psychological dimensions and their influencing factors on safety culture among mine workers and mine owners in Malaysia could help minimise mine accidents in Malaysia and create a safer place to work.

2) The influencing factors of the situational dimension are important to creating a safety culture framework for the Malaysian mining industry.

In Malaysia's context, mining is significant to the nation's economic growth. Malaysia is blessed with various minerals, such as gold, tin ore, iron ore, and bauxite. For example, according to the Mineral Geoscience Department's (Jabatan Mineral dan Geosains Malaysia [JMG] Annual Report, 2021), Malaysia's total mineral reserves were RM4.11 trillion. It consisted of 785.5 million metric tonnes of metallic minerals worth RM 1.03 trillion, 51 billion metric tonnes of non-metallic minerals (RM1.65 trillion), 1.9 billion metric tonnes of energy minerals (RM0.12 trillion), and 43 billion metric tonnes of river and marine sand (RM1.31 trillion). All these minerals should be managed properly to avoid mining accidents or disasters. It would be a big mistake if a mining disaster occurred at a mine site and contributed losses to the nation, society, and even the environment. All these reflect the situational dimension of safety culture in *"what organization has"* to manage, monitor, and sustain all these minerals by avoiding mining disasters or accidents.

The number of industrial accident cases in the mining industry demonstrated a fluctuating trend from 2009 until 2019 (SOCSO, 2019). The average number of mine accidents reported within a 10-year period of time is 374 mine accidents per year, according to the Department of Occupational Safety and Health (DOSH) Malaysia (SOCSO, 2019). According to the DOSH Annual Report (2019), human error, mechanical failure, and geological factors like landslides are the main causes of mine accidents in Malaysia. In regards to this issue, various research studies on mine accidents have been conducted worldwide, and one of the promising ways to reduce mine accidents is by promoting a positive safety culture among mine workers (Miao et al., 2020; Stemn et al., 2020; Zhang, Fu, Hao, Fu, Nie, and Zhang, 2020; Fu et al., 2019).

However, there is less understanding of the situational *dimension* of *"what organisations have,"* especially among mining companies in Malaysia. This is required to overcome those mining accidents in Malaysia. According to Grote (2018), safety culture should play into high-level decisions, including safety investments, resources, and budget allocations. The importance of an organisational structure and safety culture was discussed by Schulman (2020). According to Zheng and Jiang (2012), as well as Stemn, Bofinger, Cliff, and Hassall (2019), managing occupational health and safety in the mining industry is essential for reducing mine accidents, as reported by. However, the lack of studies on the situational dimension of safety culture in the mining industry in Malaysia gives researchers a great opportunity to further investigate this study. A good understanding of the *"what organization has"* of mining companies in Malaysia, what they currently practice to support safety culture, and the influencing factors of safety culture at their mine workplace is important to ensure mining accidents or disasters can be prevented in the Malaysian mining industry. All these inputs are important in constructing a good safety culture framework, which is the main objective of this study.

(3) The influencing factors of the behavioural dimension are important to creating a safety culture framework for the Malaysian mining industry.

A good understanding of the influencing factors of safety culture in the behavioural dimension is important for the Malaysian mining industry. It focuses on *"what the people do"* to develop good safety culture practices according to the Cooper Model (Cooper, 2000). Good cooperation between top management and workers is important for a behavioural safety culture (Jiang et al., 2020). Previous scholars reported on organisational deficiencies (Quansah et al., 2023; Sanmiquel-pera & Bascompta, 2019), poor leadership of management (Xiang, 2019), lack of safety training (Jiang et al., 2020), poor safety management (Jiang et al., 2020; Pon, 2016), and lack of safety rules and regulations (Quansah et al., 2023) as examples of poor behavioural dimensions. Poor behavioural dimensions of mining companies led to poor safety culture practices.

To date, lack of studies have been conducted on behavioural safety culture in the Malaysian mining industry, and there is a huge gap to be filled immediately. The necessity of having a clear framework for safety culture in the mining industry in Malaysia is demanding, especially in reducing the number of mining accidents. Moreover, there has been a lack of scientific articles focusing on the mining industry in Malaysia for the past 30 years and a lack of studies specifically reporting on behavioural safety culture in Malaysia. It is quite challenging to penetrate and understand the existing practices in the behavioural safety culture of mine workers in Malaysia. This situation has driven researchers to investigate *"what the people do"* under the behavioural dimension for mining industries in Malaysia, their current practices related to the behavioural dimension, and the influencing factors on practicing a behavioural safety culture. All these inputs are beneficial in constructing a safety culture framework for the mining industry in Malaysia.

Therefore, the research study aims to investigate the influencing factors of the psychology, situation, and behaviour of safety culture and to construct a framework of safety culture for the mining industry in Malaysia.

1.3 Research Questions

The research questions (RQ) were formulated as follows:

RQ1. What are the main influencing factors for psychological, situational and behaviour dimensions used to develop the safety culture framework for mining industry of Malaysia? (Systematic review, Qualitative study, and Quantitative study)

RQ2. What are the most significant influencing factors that contribute to the construction of a safety culture framework in Malaysia? (Quantitative study)

RQ3. To what extent could the proposed framework for safety culture have a significant impact on the mining industry in Malaysia? (Qualitative study and Quantitative study.

1.4 Research Objectives

The research objectives were listed below:

1) To investigate the influencing factors of psychological, situational and behavioural dimensions on the safety culture prevailing in the mining industry in Malaysia.
2) To develop a framework for safety culture in the mining industry in Malaysia.
3) To validate the proposed safety culture framework for the mining industry in Malaysia.

1.5 Scope of the Study

For Objective 1,

i. This study focus on Systematic Literature Review (SLR), preliminary study, Delphi I, Delphi II to achieve Objective 1.
ii. The volunteered respondents of study consist of mining experts, academician and government employers have at least minimum 10 years of working experience in mining industry.
iii. Malaysian Standard (MS) ISO 45001:2018 Occupational health and safety management systems - Requirements with Guidance for Use, Malaysian Standard MS1722 Occupational Safety and Health Management Systems (OSHMS) and Occupational Safety and Health Work Assessment (OSHWA) were used as a main reference for study.
iv. The instrumental used was validated by experts and the data obtained were analysed quantitatively (thematic analysis) and qualitatively (statistical analysis).

For Objective 2,

i. A set of AHP questionnaires was distributed to mining experts which focused primarily on the influencing factors of psychological, situational, and behavioural dimensions. The validation of questionnaire was validated by AHP experts.

For Objective 3,

i. Focus Group Discussion (FGD) and case study at a volunteer mining company were conducted to validate a proposed framework for safety culture in the mining industry.

1.6 Research Hypothesis

The research hypothesis of the study is that the safety culture framework is significant as an accident prevention mechanism for the Malaysian mining industry.

1.7 Thesis Outline

This thesis is divided into five chapters. In Chapter 1, the research background, research problem, objectives, research questions, scope of the study, and hypothesis of this research are addressed. Chapter 2 provides an overview of the main causes of mine accidents, the mining industry in Malaysia, the concept of safety culture, and the various safety culture models available. It also includes the Systematic Literature Review (SLR) and synthesises existing literature on global safety culture in the mining industry. Chapter 3 discusses the research design, incorporating both qualitative and quantitative methods. Chapter 4 unveils the results and analysis derived from the preliminary study, Delphi Technique, and Analytical Hierarchy Process (AHP). The validation of the safety culture framework was accomplished through focus group discussions and a case study conducted at a mining company, highlighted within this chapter. Finally, Chapter 5 encapsulates the conclusion and offers recommendations for the overall research.

CHAPTER 2

LITERATURE REVIEW

This chapter provides a comprehensive literature review on mining, the concept and model of safety culture, and the main dimensions used for the safety culture framework study in the context of Malaysia. The first section offers the concept of safety culture and an analysis of safety culture theories. The examples of safety culture models include Bandura's Theory and Reason's Theory. These theories were used as guidance to understand the knowledge of safety culture. The second section touches on the mining industry in Malaysia, governing laws and regulations related to mining, and the timeline of current safety culture studies in Malaysia. The third section provides the systematic literature review (SLR) on influencing factors of safety culture in mining industry and thematic analysis used to develop the main theme and sub-themes. This SLR was used as the foundation of this research to establish the framework for safety culture for the mining industry in Malaysia.

2.1 Concept of Safety Culture on Accident Prevention

Human factors, environmental conditions, technical failures (Greenwood and Woods, 1919; Shaw and Sichel, 1971; Sutherland and Cooper, 1991; Clarke, 2000), and hazard control technologies (DeJoy, Schaffer, Wilson, Vandenberg, and Butts, 2004) are the main and earliest research areas on safety. Most disasters occurred due to poor management, policies, and procedures (Barling, Kelloway, and Iverson, 2003; Cox and Cheyne, 2000; Hayes, Perander, Smecko, and Trask, 1998; Parker, Axtell, and Turner, 2001). Later on, the research concerning safety was shifted to safety culture (International Atomic Energy Agency [IAEA], 1986; Hale and Hovden, 1998).

Despite its origin in the Chernobyl (IAEA, 1986) accident investigation, it is uncommon for safety culture to be directly addressed in investigations of accidents. Strauch (2015) believes that due to limitations in defining and measuring, the direct assessment of safety culture during accident investigations may produce misleading results:

"Investigators need to establish a cause-and-effect relationship in an accident, relying on identifiable performance measures, and the presence or absence of such aspects of an organization's culture…does not satisfy the need for a logical, direct link between a factor and the accident, nor is that a readily identifiable parameter." (Strauch, 2015)

However, post-accident investigations may provide the opportunity to identify more aspects of an organisation's safety culture. In various industries, it is becoming increasingly common for companies and researchers to apply safety culture retroactively to explain accidents and incidents (Strauch, 2015). For example, Vaughan (1996) rejected the prevalent explanations of the cause of the NASA Challenger disaster and used safety culture to identify the root causes of the failure. Antonsen (2009) found that accident investigation reports on an offshore drilling platform better described the organisation's safety culture, in contrast to measures of perceived safety obtained through traditional assessments.

Furthermore, according to Bloch (2012), there are four main phases of safety research in the mining industry. The first phase of safety is safety engineering, and the second phase is focused on policies, procedures, and safety regulations in the mining industry. These phases concurred that human factors were to blame for 95% of mining accidents and incidents (Bloch, 2012). The traditional approach to accident prevention, which places a heavy emphasis on safety engineering and human error, has changed to a culture-based approach that embeds behavioural safety culture and transforms safety concerns to reduce mining accidents in the upcoming phases. Behaviour-Based Safety (BBS), which places a strong emphasis on changing human behaviour to increase safety, is the name given to the third phase. At this time, the idea of a safety culture was also being considered by several global companies to reduce the likelihood of catastrophic events and accidents (Cooper, 2000).

The fourth stage is referred to as "culture-based behavioural safety," which combines the transformation of safety-related issues with a culture of behavioural safety. The success of this phase depends on changing the corporate culture of a mine, enhancing safety and production, and creating a safe environment. It also depends on using worker cultures to win over people to the cause of safe production. Engagement at all levels fosters strong relationships and keeps everything on the best interests of the business and its stakeholders as a whole (Bloch, 2012).

Moreover, the Bradley curve model (Dupont, 1995), with safety practice level and safety culture phases (DSS Bradley Curve Infographic, 2021), was divided into five stages: (i) stage reactive, (ii) stage dependent, (iii) stage independent, and (iv) stage interdependent, as shown in Figure 2.1. For example, to achieve the interdependent safety culture phase, the voluntary participation and high-level risk management are required. At this stage, the safety practice level is at its maximum and results in the lowest injury rate. To achieve it, cooperation between employer and employees as a team with a higher level of safety culture practises is required. Therefore, the number of accidents can be reduced.

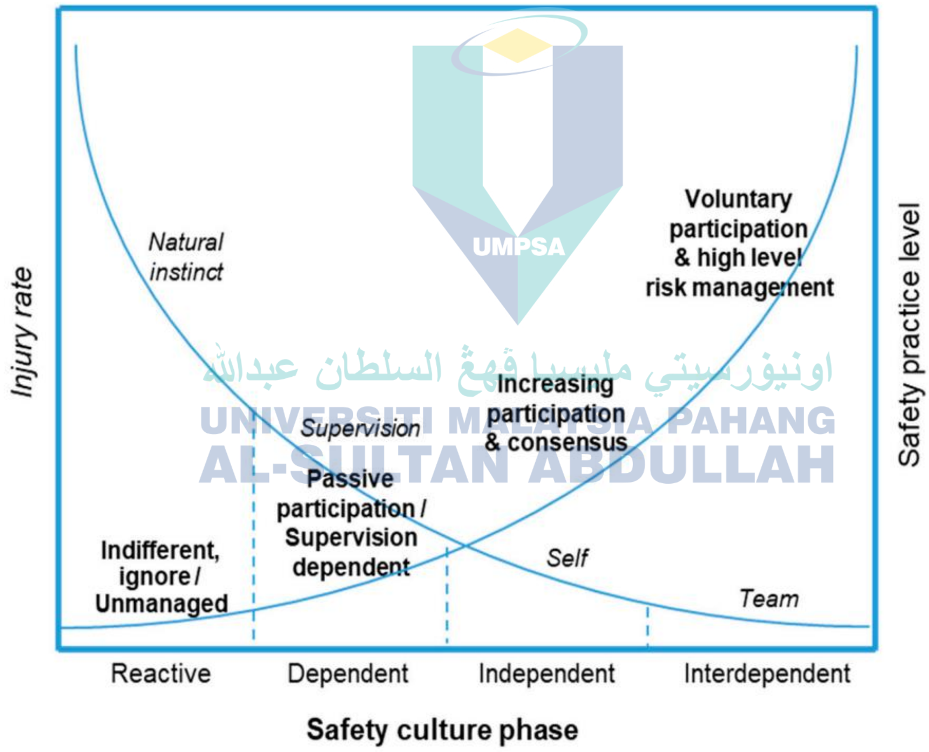


Figure 2.1 Bradley curve model with safety practice level and safety culture phases
Source: Dupont (1995), DSS Bradley Curve Infographic (2021).

Safety culture is defined in a variety of ways within academic research literature and across different industries, as shown in Table 2.1.

Table 2.1 Various definitions of safety culture

Type of Definition	Definition	Ref
Theoretical definition	Shared and learned meanings, experiences, and interpretations of work and safety - expressed partially symbolically which guide people's actions towards risk, accidents, and prevention.	Richter and Koch (2004)
Theoretical definition	Safety culture is the enduring value and priority placed on worker and public safety by everyone in every group at every level of an organisation. It refers to the extent to which individuals and groups will commit to personal responsibility for safety, act to preserve, enhance, and communicate safety concerns, strive to actively learn, adapt, and modify (both individual and organisational) behaviours based on lessons learned from mistakes, and be rewarded in a manner consistent with these values.	Weigmann, Zhang, and Thaden (2002)
Theoretical definition	The set of assumptions and their associated practices, which permit beliefs about danger and safety to be constructed.	Pidgeon (2001)
Theoretical definition	Safety culture is that observable degree of effort by which all organisational members direct their attention and actions toward improving safety on a daily basis.	Cooper (2000)
Theoretical definition	Those aspects of the organisational culture which will impact on attitudes and behaviours related to increasing or decreasing risk.	Guldenmund (2000)
Theoretical definition	The attitudes, beliefs, and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems.	Hale (2000)
Mineral industry	Safety culture refers to the formal safety issues in the company, dealing with perceptions of management, supervision, management systems, and perceptions of the organisation.	Minerals Council of Australia (1999)

Sources: Richter and Koch (2004), Weigmann, Zhang, and Thaden (2002), Pidgeon (2001), Cooper (2000), Guldenmund (2000), Hale (2000), Minerals Council of Australia (1999)

2.1.1 Historical View of Safety Culture's Evolution in Mining

The term ‘safety culture’ was first used in the International Atomic Energy Agency’s ([AEA] (1986) ‘Summary Report on the Post Accident Review Meeting on the Chernobyl Accident’ where safety culture was described as: *"That assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance."* (International Atomic Energy Agency [IAEA], 1991*)*. Figure 2.2 depicts the emergence of safety culture in mining from a historical perspective. The way that safety and risk management are viewed and applied has changed, and this is reflected in the way that safety cultures have developed within the mining sector.

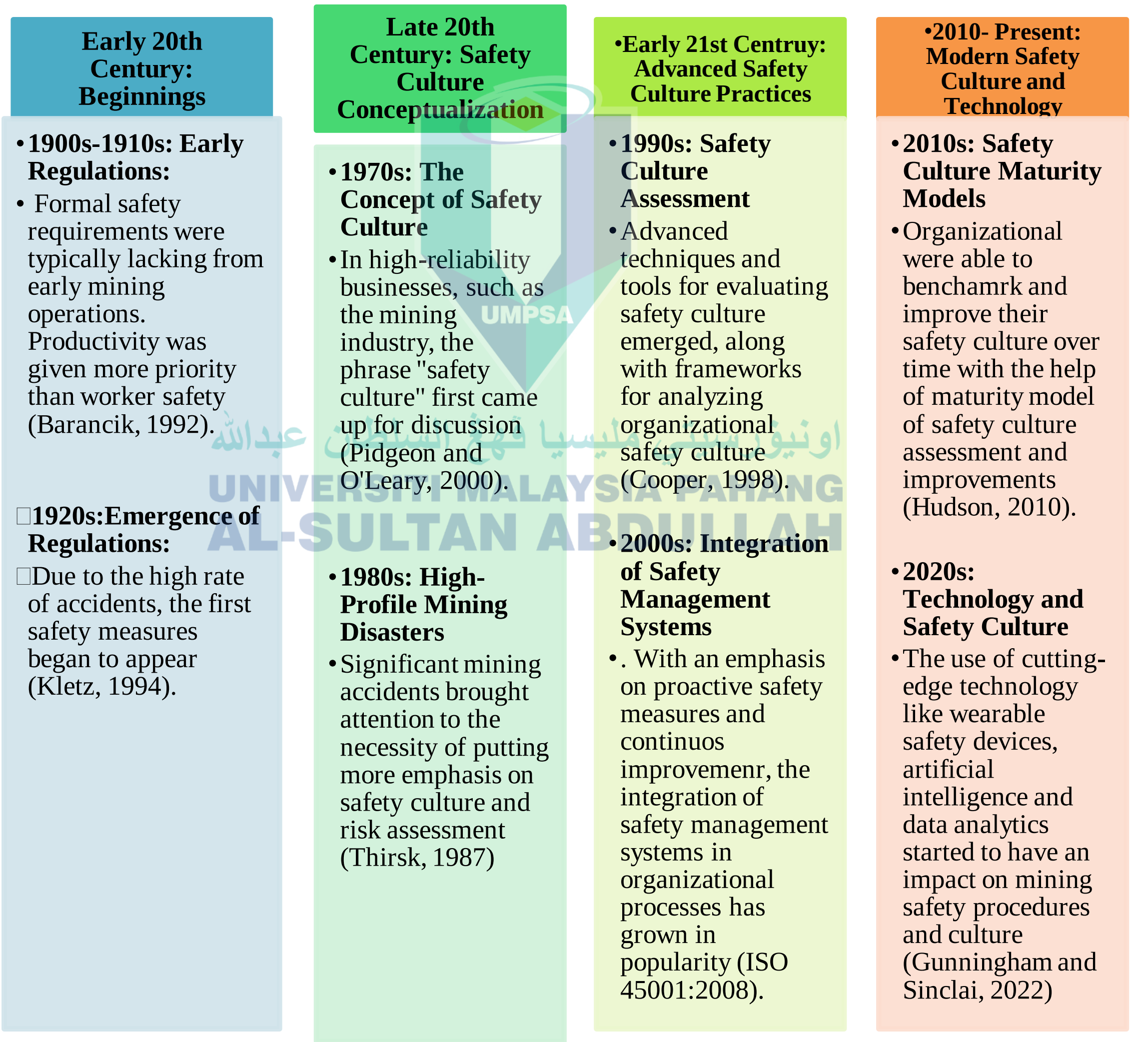


Figure 2.2 Timeline of Safety Culture’s Evolution in Mining Industry

Sources: Barancik (1992), Kletz (1994), Pidgeon and O'Leary (2000), Thirsk (1987), (Cooper, 1998), ISO 45001 (2008), Hudson (2010), Gunningham and Sinclai (2022)

2.1.2 Analysis on Various Safety Culture Models

According to Cooper's definition, *"culture is a product of multiple goal-directed interactions between people (psychological), jobs (behavioural), and the organisation (situational); and safety culture is that observable degree of effort by which all organisational members direct their attention and actions toward improving safety on a daily basis"* (Cooper, 2000). Various safety culture models were developed by previous scholars, such as the Bandura Reciprocal Determinism Model (Bandura, 1986), Schein's Theory (Schein et al., 1992), Geller's Theory (Geller, 1994; Geller, 1997), Reason Safety Culture Model (Reason et al., 1997), Guldenmund's Three Layered Organisational Culture (Guldenmund, 2000), Reciprocal Safety Culture Model by Cooper (Cooper, 2000), and Reniers' Model/P2T Model (Reniers, Corcoran, Drake, Shryane, and Völlm, 2011). Figure 2.3 shows the timeline of safety culture models. To the best of the researcher's knowledge, there are no specific safety culture models for the mining industry; however, the adaptation of existing safety culture models could help to create a positive and healthy environment that can minimise accidents in the mining industry. The analysis of various safety culture models is presented in Table 2.2.

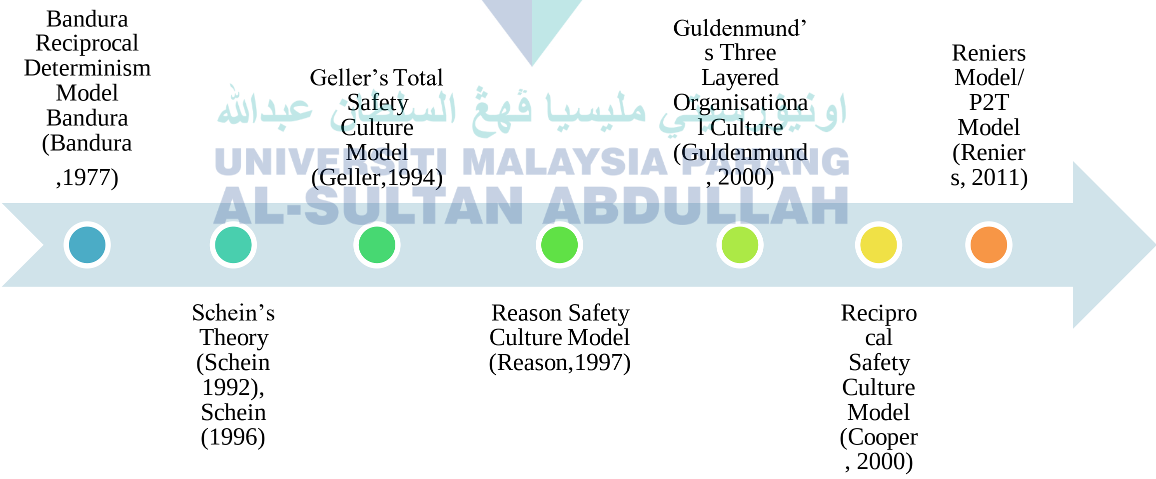


Figure 2.3 Timeline of safety culture models

Sources: Bandura (1977), Geller (1994), Schein (1992), Schein (1996), Guldenmund (2000), Cooper (2000), Reniers (2011)

Table 2.2 Analysis on each safety culture model

Safety Culture Model	Main Dimension/ Keyword	Advantages	Disadvantages	Ref
Bandura Reciprocal Determinism Model	Bandura described a triad consisting of the person, the environment (situation), and the behaviour.	In so far as they rely on cognitive supports and manage relevant contextual cues and consequences, people can self-regulate their own behaviour (Woolfson and Beck, 1999).	Focus more on people's behaviour is a product of situations (Bandura, 1977; Fang and Wu, 2013) Does not stress on the aspect of organisation's culture	Bandura (1977); Fang et al. (2013). (Woolfson and Beck, 1999).
Schein's Theory	It consists of; • Level 1: Artefacts and Creation (Technology, Art and symbolic manifestation, Visible and audible behaviour patterns. • Level 2: Values (Philosophies, morals and ideologies, Testable in the physical environment, Testable only by social consensus) • Level 3: Basic assumptions (Enshrined beliefs, Relationship to environment, Nature of reality, time and space, Nature of human nature, Nature of human activity and relationship)	Stress environment and behaviour aspects	Does not stress on the aspect of people (workers) on safety culture	Schein (1992) Schein (1996)
Total Safety Culture	Also, or known as "The Safety Triangle by Geller. It consists of; 1) Person – knowledge, skills, abilities, intelligence, motives. Personality 2) Environment- equipment, tools, machines, housekeeping, heat - cold engineering 3) Behavior – complying, coaching, recognising, communicating, demonstrating "Actively caring"	Stress on person, environment, and behaviour aspects	Does not stress on the aspect of organisation's culture and workers' perceptions on safety culture	(Geller,1997)
Reason Safety Culture Model	Consists of five main subcultures; 1. Informed culture - who manage and operate the system have current knowledge and environmental factors that determine the system as a whole. 2.Reporting culture - and organisation climate in which people are prepared to report their errors and misses. 3. Just culture - an atmosphere of thrust in which people are encouraged (even rewarded) for providing essential safety-related information, but in which they are also clear about where the time must be drawn between acceptable and unacceptable behaviour. 4. Flexible culture - a culture in which an organisation is able to reconfigure themselves in the face of high tempo operations or certain kinds of danger-often shifting from the conventional hierarchical mode to flatter mode. 5. Learning culture - An organisation must possess the willingness and the competence to draw the right conclusions from its safety information system and then, will implement major reforms	Stress on the aspect of organisation's climate.	Does not stress on the aspect of organisation's culture and people (workers) perceptions on safety culture	(Reason, 1997)

Table 2.2 Continued

Safety Culture Model	Main Dimension/ Keyword	Advantages	Disadvantages	Ref
Guldenmund's Three Layered Organisational Culture	Also known as The Three-layered Organisational Culture Framework. It consists of; • The bottom layer consists of unconscious and nonspecific (invisible) core basic assumptions about safety, where suppositions regarding safety are not expressed, but are taken for granted as the basis for arguments or actions. • The intermediate layer reflects espoused ideas and values that are operationalised as relatively explicit and conscious attitudes whose objective is hardware (safety controls), software (efficacy of safety arrangements), people (functional groupings), and people's safety-related behaviours. • The top layer's artefacts are the manifestations of the preceding two layers, which reflect all visible safety objects (e.g. PPE, inspection reports, safety signage, etc.) without which Schein (1996) claims it would be difficult to appreciate an entity's safety.	• the model recognises that the overall organisational safety culture was made up of distinct subcultures, these basic assumptions differ for executives, engineers, and operators • The focus of this model, on the other hand, is on determining what a company's safety culture is and what it means to its employees	• In practice, however, most assessments use a safety survey technique to learn about people's attitudes (often in combination with interviews and focus groups), with only a handful evaluating visual artefacts. • The underlying basic assumptions are deduced exclusively by the assessor(s) from the assessment results, which have shown to be extremely difficult, if not impossible (Guldenmund, 2000).	Guldenmund (2000)
Reciprocal Safety Culture Model	Consists of; • Psychological / People / Person Dimension: Refers to the "How People Feel" for individual and group values, attitudes, and perceptions about safety (Cooper, 2000) • Situational / Organisational / Working Environment Dimension: Refers to "What Organisational Has" including policies, regulation, organisational structure, and management systems (Cooper, 2000) • Behaviour Dimension: Refers to "What People Do" such as safety related actions and behaviour, safety leadership (Cooper, 2000)	• The most often utilised safety culture model in safety culture research (Cooper, 2000). . • Focus on interaction between safety culture's psychological, environmental, and behavioural aspects.	NA	(Cooper, 2000)
Reniers Model/ P2T Model	P2T stands for People, Procedure, and Technology. Consists of; • People - behaviour, cooperation, training etc. • Procedure - safety management system, guidelines, regulations, work instructions and • Technology - safety technology and equipment also software for risk assessment etc.	Stress on people, procedures, and technological aspect of safety culture.	Does not stress on the aspect of workers' perceptions on safety culture.	(Reniers, 2011)

Sources: Bandura (1977), Fang et al., (2013), Woolfson and Beck (1999), Schein (1992), Schein (1996), Geller (1997), Reason (1997), Guldenmund (2000), Cooper (2000), Reniers (2011)

Based on an analysis of safety culture models, the researcher adopted the Cooper Model (2000), as shown in Figure 2.4, because it clearly defines the three main dimensions of psychological, situational, and behavioural dimensions that must co-exist to form a framework of safety culture. Based on Copper (2000), the psychological dimension stresses *"how people feel/care"* about the employee's perception and how the employer portrays their concern for the emotions and perceptions of their employees towards safety culture.

In addition, the situational dimension focuses on *"what the organisation has"*, which means the effort of the company or employer to provide such things as a clear safety policy, good facilities, and a proper working area to their employees in order to establish a good safety culture at the workplace. Meanwhile, the behavioural dimension reflects *"what people do"*, which means the action of the management to conduct or execute any activities towards establishing a safety culture at the workplace, such as safety programmes and safety awareness.

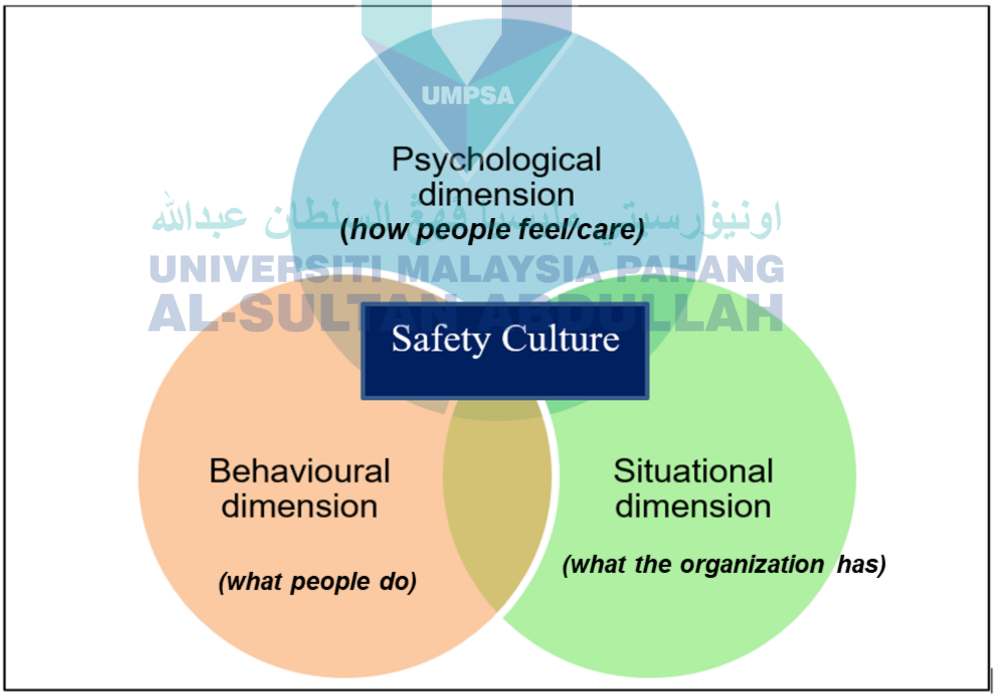


Figure 2.4 Cooper Model (2000)
Source: Cooper (2000)

2.1.3 Organisational Culture Versus Organisational Climate

Reichers and Schneider (1990) define organisational climate as "shared perceptions of organisational polices, practises, and procedures, and describe organisational culture in terms of shared meanings or understandings about the organisation and its problems, goals, and practises". However, during the 1980s the term "*organisational climate*" was shifted to a new term called "*organisational culture*" (Guldenmund, 2000). Moreover, according to Schein (1992), organisational culture is defined as deeply established ideas about human nature, human activity, and social interactions shared by members of an organisation, as well as their manifestation in values, behavioural patterns, and artefacts found inside the organisation.

A lot of debate is still ongoing about how to differentiate between organisational culture and organisational climate. One of the famous definitions of organisational culture is introduced by Schein (1989). He refers to organisational culture as "*a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems*" (Schein, 1992) which become norms, and the norms tell the members of the organisation about the correct attitudes and actions. However, organisational climate refers to the perceptions of people in the organisation that reflect those norms, assumptions, and beliefs. Climate is replaced by culture, and culture then expresses a broader and more profound meaning.

Ekvall (1983) distinguishes organisational climate from organisational culture. He introduced four main organisation social systems into four main criteria, which depend on each other and can be differentiated as below;

i. organisational culture, such as values and beliefs about work, people, and organisation;
ii. social structure, such as the informal organisation;
iii. organisational climate, such as common behaviours and expressions of feelings by organisational members
iv. work relations, such as the nature of the relationship between employees and management

Moreover, according to Ashforth (1985), the organisational climate and organisational culture are closely related and sometimes quite difficult to separate. Despite this, the differences are, in fact, real and meaningful. The culture influences the climate through values and norms that are based on assumptions and convictions established on a deep psychological level. Individuals within the organisation receive information about the behaviours and attitudes that are considered acceptable. This has an impact on the kind of climate that evolves. The culture can be regarded as possessing affecting abilities that are present in the background. In this way, the organisational climate is considered to be derived from the organisational culture.

Denison (1996) concludes that both concepts have quite similar problems related to safety concerns. Individual interaction in social contexts has a great influence on portraying both concepts. Moreover, Schein's (1989) definition of culture focuses on how social contexts develop out of interaction, while the climate approach is more likely to focus on the perceptions of social contexts and their impact (Denison, 1996). Despite the differences between the concepts, Denison (1996) illustrates that they share a common basis in explaining the relationships that exist among groups of people who share some sort of common situations. Because the nature of culture is so deep and inaccessible, the concept of climate is considered to be more closely in touch with reality. Schein (2000) claims that the climate can only be changed to the degree that the desired climate is congruent with the underlying assumptions. One cannot, for example, create a climate of teamwork and cooperation if the underlying assumptions in the culture are individual and competitive, because those assumptions will have created a reward and control system that encourages individual competitiveness.

Furthermore, both concepts have different approaches or methodologies for measuring them. For example, organisational culture research mostly utilises the qualitative method, while organisational climate research mostly uses the quantitative method (Guldenmund, 2000). Glick (1985) argues that research on organisational climate developed primarily from a social-psychological framework, while culture is rooted firmly in anthropology. Organisational culture can thus be described as a global, integrating concept underlying most organisational events and processes, whereas organisational climate can be described as the overt manifestation of culture within an organisation. Climate follows naturally from culture, according to Guldenmund (2000), or, put another way, organisational culture expresses itself through organisational climate.

2.1.4 Safety Culture and Safety Climate

Industries around the world are showing an increasing interest in the concept of safety culture as a means of reducing the potential for large-scale disasters and accidents (Cooper, 2000). Safety culture, which is primarily aimed at preventing organisational accidents (as opposed to individual accidents), focuses on the root causes of accidents, not the symptoms of accidents, leading to a more effective accident prevention strategy (Abdelhamid and Everett, 2000). Considering the numerous Occupational Health and Safety (OHS) reports published to date in the mining industry, there is a need to determine how safety culture has been framed in the context of causation and prevention. The relationship between safety culture and safety climate in organisational culture and organisational climate research has been extensively studied. A safety culture has an important role in high-level decisions such as investments, resource and budget allocations, and should also cater to work assignments, work planning, individual job descriptions, roles, and personal identities in terms of safety concerns (Grote, 2018; Sorensen, 2002).

It is useful to distinguish between safety culture and safety climate. Weigmann (2004) defines safety climate as "*the temporal state measure of safety culture, subject to commonalities among individual perceptions of the organization*." It is therefore situational-based, refers to the perceived state of safety at a particular place and time, is relatively unstable, and is subject to_change depending upon the features of the current environment or prevailing conditions". He also defines safety culture as "*the enduring value and priority placed on the worker and public safety by everyone in every group at every level of an organization*." This refers to the extent to which individuals and groups will commit to personal responsibility for safety, act to preserve, enhance, and communicate safety concerns, and strive to actively learn, adapt, and modify (both individual and organisational) behaviours based on lessons learned from mistakes, and be rewarded in a manner consistent with these values (Weigmann and Thaden, 2002). Schein conceives of climate as preceding culture. He argues that climate is culture in the making. Further on, Schein writes that "*climate will be a reflection and manifestation of cultural assumptions*". Climate is replaced by culture, and culture then conveys a broader and more profound meaning. Figure 2.5 shows an illustration of the differences between safety culture and safety climate.

As in the differentiation between organisational culture and organisational climate, safety culture tends to focus on a deeper psychological level than safety climate and deals with shared core values, norms, and attitudes based on assumptions and convictions about safety in the organisation (DeJoy et al. 2004). The safety climate concept can be regarded as a specific form of organisational climate. An emerging consensus tends to differentiate safety climate from safety culture, implying that safety climate consists of an organisation's underlying safety culture as assessed by the workforce's attitudes and perceptions at a given point in time (Flin, 2003). Safety climate emphasises shared perceptions held by employees regarding the importance of safety in their work environment and organisation (Denison, 1996; Guldenmund, 2000; Weigmann et al. 2004).

While safety culture represents long-term attitudes, beliefs, and the stable ways in which people behave, safety climate represents a snapshot of the current state of these factors at any one time (Flin, Mearns, O'Connor, and, Bryden, 2000). Thus, a safety climate is something that an organisation has at a time. The most commonly measured climate dimensions are those related to management, risk, safety arrangements, procedures, training, and work pressure. It is noted that the use of the term safety climate appeared prior to the use of the term safety culture in the literature. The summary table on differences between safety culture and safety climate by Wiegmann et al. (2004) is shown in Table 2.3.

Both a safety climate and a safety culture are essential in the mining sector for averting disasters and guaranteeing employee wellbeing. While a favourable safety climate reflects and upholds employee priorities for safety, a strong safety culture integrates safety into business principles. In high-risk settings like mining, effective management of both ideas results in better safety outcomes and lower risk. Mining companies can improve their overall safety performance and develop more effective safety management strategies by incorporating the insights from these sources to gain a deeper understanding of the dynamics of safety culture and climate (Guldenmund,2000)

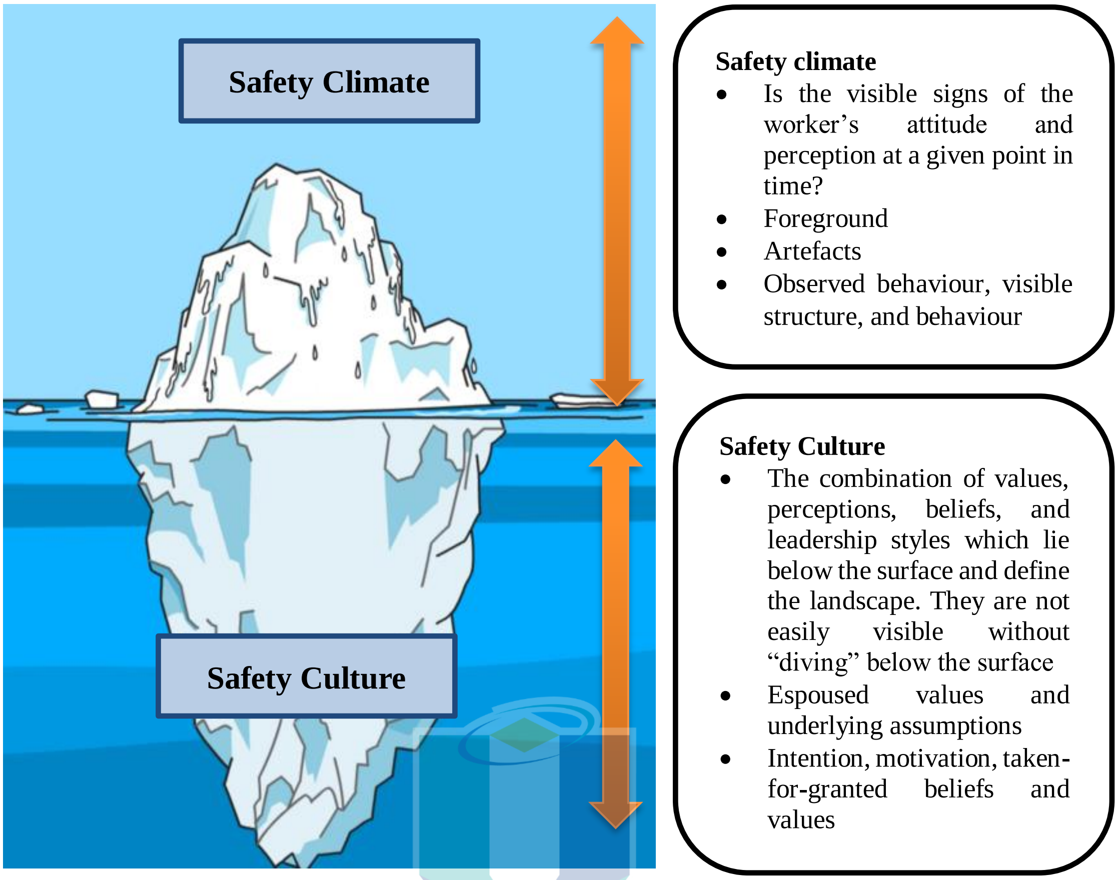


Figure 2.5 Iceberg of Safety Culture and Safety Climate

Source: Weigmann and Thaden (2002).

Table 2.3 Differences of Safety Culture and Safety Climate

Safety culture	**Safety Climate**
• A concept defined at a group level • Shared values among all the group or organisation members • Concerned with formal safety issues • Closely related to the management and supervisory systems • Emphasise the contribution from everyone at every level • Impact member's behaviour at work • Reflected in the contingency between reward systems and safety performance • Organisation's willingness to learn from errors and incidents • Enduring, stable, and resistant to change	• A psychological phenomenon defined at a particular time • Concerned with intangible issues such as situational and environmental factors • Temporary manifestation or *snap shot* of safety culture. • Unstable and subject to change

Source: Weigmann et al. (2004).

2.2 Safety Culture Studies in Malaysia in the Malaysian Mining Industry

2.2.1 Current Status on Malaysian Mining Industry and Its Contribution

Malaysia has been blessed with abundant mineral resources such as gold, tin, coal, iron ore, limestone, copper, feldspar, sand, silica sand, kaolin, and manganese that are economically exploitable (Jabatan Mineral dan Geosains Malaysia [JMG] Annual Report, 2019). Back to history, tin mining is one of the oldest industries in Malaysia. Tin mining was started in the 1820s in Perak, followed by Selangor in 1824. Malaysia exported almost 63,000 tonnes of tin in 1979, contributing 31% of the world's demand (JMG, 2019). Three main categories of minerals to be mined are metallic minerals, non-metallic minerals, and energy minerals. Metallic minerals include gold, tin, copper, iron, aluminium, manganese, rare earth minerals, silver, tantalum (niobium) minerals, titanium, and zircon. For non-metallic minerals: aggregates, barytes, bentonites, clays, gypsum, and anhydrite, kaolin, limestone, mica, phosphate rock, sand and gravel, as well as silica. Coal is categorised as an energy mineral (JMG, 2019).

Currently, there are 161 mines and 201 quarries operating nationwide. The number of holders of Minerals License and Mineral Processing License is 252 and 77, respectively (JMG, 2019). The estimated value of Malaysia's mineral reserves is RM4.11 trillion, with 785.5 million tonnes of metallic minerals worth RM 1.03 trillion, 51 billion tonnes of non-metallic minerals (RM1.65 trillion), 1.9 billion tonnes of energy minerals (RM0.12 trillion), and 43 billion tonnes of river and marine sand (RM1.31 trillion). In addition, there are currently 91,000 miners in Malaysia (JMG, 2019). The modern mining industry has five activities consist of prospecting, exploration, development, exploitation, and reclamation as illustrated in Figure 2.6.

1. Prospecting	• To locate the exact location of ore exists using geographical location
2. Exploration	• To obtain accurate size and value of targeted mineral deposit
3. Development	• Involves the activities for opening a mineral deposit for exploitation either surface or underground mining
4. Exploitation	• Recovery of mineral deposit
5. Reclamation	• Involves the closing activities for a mine including re-contouring, • re-vegetating and restoring the water and land values

Figure 2.6 Mining industry's life cycle and main activities

Source: Hilson (2000)

2.2.2 Malaysian Legislatives related to Safety Culture in Mining Industry

In Malaysia, a mineral is legally defined as any substance whether in solid, liquid, or gaseous form occurring naturally, as a result of mining in or on the earth, or as a result of mining in or under the sea or seabed, formed by or subject to a geological process, but excludes water, rock material as defined in the National Land Code, and petroleum as defined in the Petroleum Mining Act 1966 (Semasa and Dan, 2014). There are two main legal instruments related to mineral activities: (i) the Mineral Development Act 1994 for the federation and (ii) the Mineral Enactment (Various States) for each state in Malaysia. The Mineral Development Act 1994 came into force in August 1998, while the State Mineral Enactment has been adopted by the respective State Governments except for Sabah and Sarawak, ranging from 2001 to 2004.

The Mineral Development Act 1994 defines the powers of the Federal Government for inspection and regulation of mineral exploration and mining and other related issues (Semasa and Dan, 2014). It is the primary legislation that governs mining-related activities in Malaysia. The legislation is enforced by the Department of Mineral and Geoscience of Malaysia (JMG). JMG performs enforcement, issues licenses and permits, and monitors mining and quarry operations in Malaysia (JMG, 2019).

Malaysia's legislative context plays a significant role in shaping safety culture in the mining industry. Table 2.4 shows the summary of regulatory framework, safety regulations and standards which is important for safety culture in Malaysian mining industry. For examples, Modul Latihan Lombong dan Kuari JKKP contributes to enhancing safety culture in Malaysia's mining industry by improving training, compliance, and safety practices

Table 2.4 Malaysia legislatives related to safety culture in mining industry

Category	**Name**	**Objective**	**Main aspects**	**Ref**
Regulatory Framework	Occupational Safety and Health Act (OSHA) 1994	to create a safer work environment, minimize health risks, and protect the well-being of the workforce.	The fundamental component of Malaysian occupational safety law is this statute. It lays out the general responsibilities of employers, workers, and other parties involved in maintaining a secure workplace. In order to comply with OSHA 1994, mining businesses must set up and keep up strong safety procedures, which promote a safety-conscious culture.	Occupational Safety and Health Act (OSHA,1994)
	Minerals Development Act 1994	To ensure that mineral resources are developed in a responsible, sustainable, and economically beneficial manner while balancing the needs of various stakeholders.	The mining exploration and extraction processes in Malaysia are regulated by this act. Its safety, health, and environmental management regulations have a direct impact on the safety culture and practices of the mining industry.	Minerals Development Act 1994 (MDA, 1994)
	NADOPOD, which stands for "Notification of Accidents, Dangerous Occurrence, Occupational Poisoning, and Occupational Disease"	a key regulatory framework introduced in Malaysia in 2004 to enhance safety and health standards in the mining industry. It was designed to address the growing concerns over safety and to improve the overall safety culture within the industry	Focus on • improving mine safety and health management practices. • Enhancing Safety Practices • mandated training and competency development for personnel involved in mining operations. • Safety Audits and Compliance • Encouraging Reporting and Communication	Lee and Tan (2008)

Table 2.4 Continued

Category	Name	Objective	Main aspects	Ref
Safety regulations and Standard	Malaysian Standard (MS) ISO 45001:2018 Occupational health and safety management systems - Requirements with Guidance For Use	provides a structured framework for developing a safety management system.	Relationship Between MSISO450001:2008 and Safety Culture in mining including; • Risk Management and Safety Practices • Compliance and Safety Culture Alignment • Employee Engagement and Accountability • Performance Monitoring and Feedback • Integration with Organizational Culture	The Malaysian Standard (MS) ISO 45001:2018 (2018)
	Malaysian Standard MS1722 Occupational Safety and Health Management Systems (OSHMS)	The Malaysian Standard (MS) ISO 45001:2018 is an international standard for Occupational Health and Safety (OHS) management systems. It outlines requirements and provides guidance for establishing, implementing, maintaining, and continually improving an OHS management system. Its relationship with safety culture, particularly in high-risk sectors like mining, is significant for several reasons:	Relationship Between MS1722 and Safety Culture in mining including; • Leadership, • Risk management, compliance, • Training, • Communication • Continuous improvement • Standard supports	Malaysian Standard MS1722 Occupational Safety and Health Management Systems (OSHMS, 2011)
	Occupational Safety and Health and Work Assessment (OSHWA)	Conducted by employer for workplace assessment	The Department of Occupational Safety and Health (DOSH) provides guidelines and codes of practice tailored for different industries, including mining. Adherence to these guidelines helps in cultivating a safety-conscious culture within mining operations	Department of Occupational Safety and Health Malaysia (2008)
Guidelines	Hazard Identification, Risk Assessment, and Risk Control (HIRARC 2008)	Department of Occupational Safety and Health (DOSH) Malaysia to manage workplace hazards systematically	Main aspects including hazard identification, risk assessment and risk control Relationship Between HIRARC 2008 and Safety Culture in mining including • Encouraging Proactive Safety Attitudes • Integration into Daily Practices • Leadership and Communication • Employee involvement • Incident Learning and Feedback: • Continuous Improvement	Department of Occupational Safety and Health Malaysia (DOSH, 2008).

Table 2.4 Continued

Category	Name	Objective	Main aspects	Ref
Module	Modul Latihan Lombong dan Kuari JKKP (Mining and Quarry Training Module by JKKP)	is a training program developed by the Department of Occupational Safety and Health (DOSH) in Malaysia. It is designed to enhance safety awareness and practices within the mining and quarrying sectors. This training module plays a significant role in shaping safety culture in the Malaysian mining industry.	Relationship Between this module and Safety Culture in mining including; • Enhancing Safety Training and Awareness • Promoting Compliance with Safety Standards • Fostering a Safety-Oriented Organizational Culture • Improving Communication and Reporting Mechanisms • Supporting Continuous Improvement in Safety Practices • Bridging the Gap between Regulations and Practice	Department of Occupational Safety and Health Malaysia (DOSH, 2008).

Source: OSHA (1994), MDA (1994), Lee and Tan (2008), MS ISO (2018), OSHMS (2011), DOSH (2008)

In summary, Malaysia's legislative context profoundly influences safety culture in the mining industry by setting standards, enforcing compliance, and encouraging practices that prioritize worker safety and health. Adherence to these legal requirements helps foster a culture of safety, accountability, and continuous improvement in mining operations.

2.2.3 Statistics and Types of Mining Accidents in Malaysia

According to Malaysia Big Data Analytics: National Occupational Accident and Disease for Statistics Report in Year 2021 (Department of Statistics Malaysia [DOSM], 2021), there are 15.06 million employed persons, including expatriates and low skill foreign workers in Malaysia with 21,534 occupational injuries, or a 1.43 rate of occupational injuries per 1000 workers (DOSM, 2021). For the 2021 occupational injury rate, the Manufacturing sector remained the highest at 3.20 cases per 1,000 workers, followed by Construction (1.98) and Utilities (1.95). Mining and Quarrying was the only sector to record an increase in 2021 at 1.90 as against 1.48 in the previous year, as shown in Figure 2.7. The details also show that all sectors recorded a decrease in the rate of fatal occupational injuries in 2021, except for Mining and Quarrying (2021: 10.98; 2020: 3.65). Moreover, the Mining and Quarrying are the most high-risk sector for fatal occupational injuries, which recorded a rate of 10.98 per 100,000 workers in 2021 compared to 3.65 per 100,000 workers in 2020. Therefore, based on this statistic, it is important to have good safety culture practises at the workplace as a mechanism or tool for accident prevention (Jiang et al., 2020).

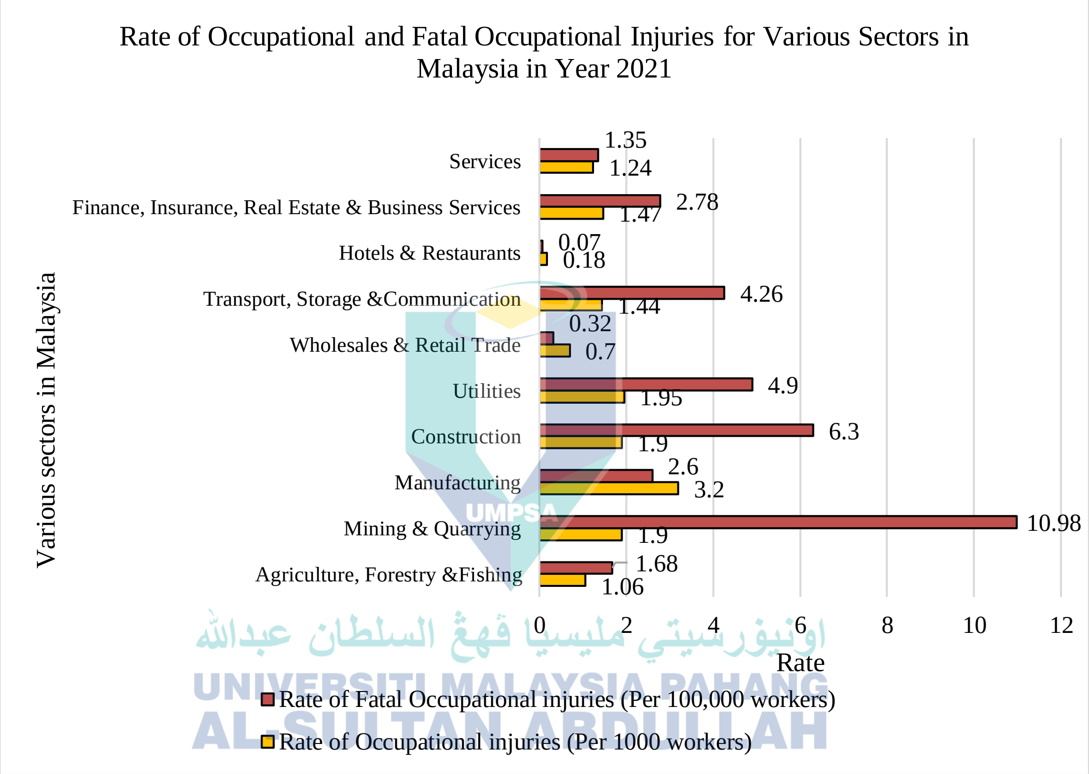


Figure 2.7 Rate of Occupational Injuries and Fatal Occupational Injuries by Sector
Source: DOSM (2021)

Moreover, the necessity to carry out this study is also in line with the objectives of the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDG) (United Nations Development Programme [UNDP], 2023). For example, according to SDG 8: Decent Work and Economic Growth, one of the targets is safeguarding labour rights and promoting safe and secure working environments for all workers. In the context of the Industrial Accidents Convention (United Nations Economic Commission for Europe [UNECE], 2016), a number of the SDGs are specifically pertinent to risk prevention, readiness, and response. Following are the primary connections between the Convention and the SDGs that can relate to the mining industry, as shown in Figure 2.8.

As we know, mining activities or operations are dealing with harsh environments with high potential risks and hazards; therefore, the study that focuses on the construction of a safety culture framework is significant. This framework of safety culture in the mining industry in Malaysia aims to ensure that mining accidents and injuries can be prevented, protect our mineral reserves, and produce responsible miners for the Malaysian mining industry. Moreover, it could help promote safe and secure working environments for all mine workers in Malaysia.

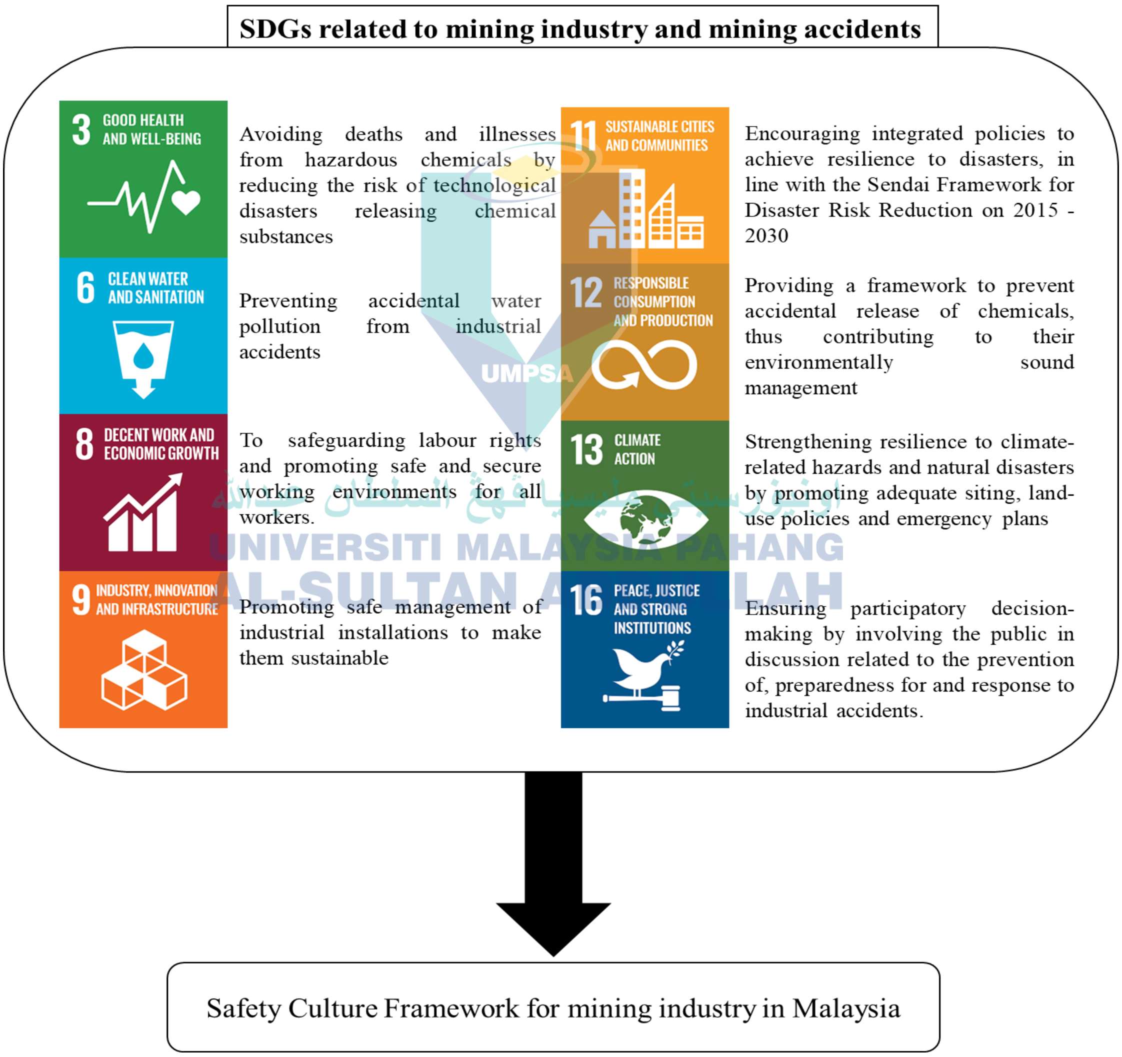


Figure 2.8 The relationship between SDG and the importance to have safety culture framework in mining industry in Malaysia

Source: UNECE (2016)

2.2.4 Main Cause of Mining Accidents in Malaysia and Other Countries

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 catastrophic share the same similarity which is having a great impact on the victims (Li, Shen, Zhou, and Xu, 2021; Lyra,2019; Gil-jiménez, Mazano, Casado, and Ferrer, 2017; Grande and Science, 2017;), mine owners (Aliabadi, Aghaei, Kalatpuor, Soltanian, and Nikravesh, 2019; Lyra, 2019; Li, Wu, Luo, Gao, and Yin, 2019; Morisson et al. 2019), mine workers (Aliabadi, Aghaei, Kalatpuor, Soltanian, and Seyedtabib, 2018; Li et al., 2019), the government (Pons, 2016; Lyra, 2019), policymakers (Liu, Cheng, Yu, and Xu, 2018; Geng and Saleh, 2015; Kong, Liu, and Xiang, 2018; Düzgün & Leveson, 2018), economic losses (Aliabadi et al. 2018; Zhu, Yao, and Yan, 2018; Gui et al. 2019; Shao, 2019; Xiao, Xu, and Lv, 2019), local community (Grande and Science, 2017; Zhu et al. 2018; Lyra, 2019), as well as the environment and human health (Prasad, Reddy, and Vadde, 2015; Clarke, 2015; Gil-jiménez et al. 2017; Grande and Science, 2017; Dam et al. 2018; Shao, 2019; Francini-filho et al. 2019; Morisson et al. 2019; Lyra, 2019; Cordeiro et al. 2019). Rahim and Hossain (2021) and Osman and Ahmad (2022) highlighted the comparison of occupational hazards and occupational safety in mining, as shown in Figure 2.9

Poor safety culture was highlighted as one of the main contributors to mining accidents. For example, a poor working environment, poor implementation, and poor enforcement led to a poor safety culture (Gui et al. 2019; Düzgün & Leveson, 2018). Furthermore, the comparison of the main causes of mining accidents in Malaysia and other countries is shown in Table 2.5. There are similarities based on the main causes of mine accidents in Malaysia and other countries. For example, most of the coal and gold mine accidents in China, Brazil, and many other countries occurred due to geological and mechanical factors. However, in the Malaysian context, according to DOSH (2019), the coal mine accidents were due to ignition sparks and inexperienced workers. Another record mentioned that gold mine accidents were due to landslides (a geological factor) (DOSH, 2019). However, because of a lack of literature and published articles related to the main causes of mining accidents in Malaysia, it is believed that safety culture is important in preventing workplace incidents or accidents by taking lessons learned from previous mining disasters or mining accidents that occurred worldwide.

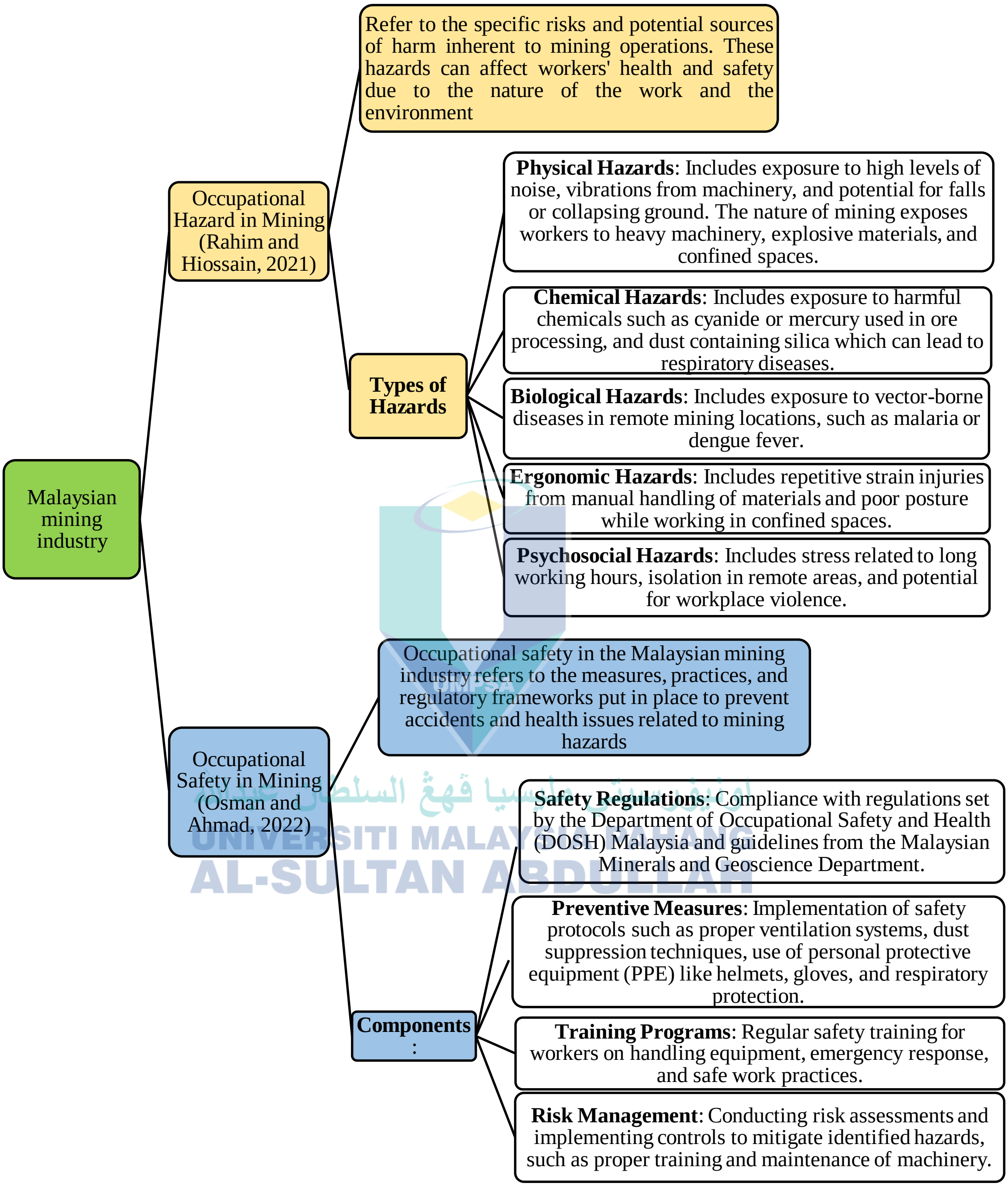


Figure 2.9 Occupational hazards and and occupational safety in mining industry

Source: Osman and Ahmad (2022), Rahim and Hiossain (2021)

Table 2.5 Main causes of mining accidents from various countries

Type of Mine Accidents	Country	Ref	Various main causes of mine accidents
Coal Mine Accidents	Malaysia	DOSH (2019)	Ignition sparks, inexperienced workers
		DOSH (2020)	Landslides due to erosion, human error, poor safety culture, lack of safety training, lack of safety education
	China	Tianwei Hongwei, Sheng, Jun, Weihua, Batugin, and Guoshui, (2015)	Geological factors, poor mechanisation
		Geng and Saleh (2015)	Human error, unsafe behaviour, lack of safety training, organisational deficiency, roof collapse, water inrush, machinery failure
		Zhang , Shao, Zhang, Li, Yin, and Xu, (2016)	Mine refuge chamber failure, unsafe conditions of the equipment, no safety device, alarm, safety signs, etc.; No protective measures, such as non-safety device, no alarm signs, no safety sign, etc.), flawed on the equipment, tools facilities, and accessories, defect on protective equipment
		Wang et al. (2016)	Lack of safety training, Lack of safety education, unsafe behaviour, problem on mining mechanisation, ventilation equipment, dust proof equipment, drainage equipment lifting and transport equipment, mechanical and electrical equipment, gas drainage equipment
		Wang, Cao , and Zhou (2018)	Machines & equipment failure
		Yu, Yin, Ma, and Shimada (2018)	Shaft lining failure
		Shi, Jiang, Meng, and Yang (2018)	Electrical, blasting, and friction sparks
		Xu and Xu, (2018)	Stroked object, mechanical injury, electric shock, crashing from the high-roof fall, wall collapsed, vehicle injury, mechanical injury
		Wang and Zhang (2019)	Rock burst
		Qiao, Li, and Liu (2019)	Gas explosion caused by electric spark, roof failure
		Tong, Yang, and Li (2019)	Ventilation problem, faulty in ventilating equipment, blasting problem, electrician working problem

Table 2.5 Continued

Type of Mine Accidents	**Country**	**Ref**	**Various main causes of mine accidents**
		Chen, Qiao and Zeng (2019)	The pillar strength was insufficient
		Gui, Ziqi, Chuanbo, and Qiang. (2019)	Blaster problem
		Qin, Li, Chen, and Cao (2019)	Rock burst due to drilling cuttings
		Xiao et al. (2019)	Electromechanical accidents.
		Xiang, Zhou, Hong, Liu, and Xu (2019)	Explosion-proof failure equipment and facilities failure, failure for explosive equipment, overload demand for replacement subsystem, failure on multiple subsystems, explosive mixture in the drift, problem in controlling equipment.
	Brazil	Cordeiro et al., (2019)	Poor design for mine tailing/dam
	Spain-	Sanmiquel-pera and Bascompta (2019)	Insufficient safety guard for electrical equipment, spark in the electrical light system, ventilation system problem
	New Zealand	Pons (2016)	Poor design for underground ventilation system
			Mine ventilation was not working well.
			Misplaced of main ventilation fan for underground
	India	Dash, Bhattacharjee, and Paul (2016)	Inrush of water/inundation
	USA	Düzgün and Leveson (2018)	Inadequate system control constraints, ventilation problems, inadequate precautions for methane explosion, mine monitoring systems failure, support systems failure
Gold Mine Accidents	Malaysia	DOSH (2019)	Landslides (geological factor), support systems failure, poor safety training
	Ghana	Clarke (2015)	Entrapment from collapse of mine pits, crushing, explosions, fires
	South Africa	Find, Persons, and Mine (2018)	Pillar collapsed
Iron Ore Mine Accidents	Brazil	Francini-filho et al. (2019)	Ore tailing dam ruptured (mechanical design)
		Lyra (2019)	Tailings dam failures (mechanical design)
		Dam et al. (2018)	Mining dam collapsed due to improper design (mechanical design)
		Grande and Science (2017)	Mining dam collapsed due to improper design (mechanical design)
	China	Morisson et al. (2019)	Mining dam failure (mechanical design)

Table 2.5 Continued

Type of Mine Accidents	Country	Ref	Various main causes of mine accidents
Iron Ore Mine Accidents	Brazil	Francini-filho et al. (2019)	Ore tailing dam ruptured (mechanical design)
		Lyra (2019)	Tailings dam failures (mechanical design)
		Dam et al. (2018)	Mining dam collapsed due to improper design (mechanical design)
		Grande and Science (2017)	Mining dam collapsed due to improper design (mechanical design)
	China	Morisson et al. (2019)	Mining dam failure (mechanical design)
Lead-Zinc Mine Accidents	Spain	Gil-jiménez et al., (2017)	Dam failure/dam burst
Platinum mine accidents	South Africa	Bonsu, Dyk, Van, Franzidis, Petersen, and Isafiade (2017)	Equipment failure

Source: DOSH (2019), DOSH (2020), Tianwei Hongwei et al. (2015), Geng and Saleh (2015), Zhang (2016), Wang et al. (2016), Wang (2018), Yu et al. (2018), Shi et a. (2018), Xu and Xu, (2018), Wang and Zhang (2019), Qiao et al. (2019), Tong et al. (2019), Chen et al. (2019), Gui et al. (2019), Qin et al. (2019) Xiao et al. (2019), Xiang et al. (2019), Cordeiro et al. (2019), Sanmiquel-pera and Bascompta (2019), Pons (2016), Dash et al. (2016), Düzgün and Leveson (2018), Clarke (2015), Find et al. (2018), Francini-filho et al. (2019), Lyra (2019), Dam et al.,(2018), Grande and Science (2017), Morisson et al. (2019), Gil-jiménez et al. (2017), Bonsu et al. (2017)

2.2.5 Current Safety Culture Studies in Malaysia and Other Countries

Safety cultures have been studied by many researchers previously as one of the mechanisms for accident prevention. The key domains of safety culture studies from various industries are summarised in Table 2.6. However, the concern about safety culture has been raised quite late in Malaysia compared to other developed countries (Mod Ali, 2008). Various industries and sectors raised issues in safety culture, which included radiation, manufacturing, electronic, construction, shipping, healthcare, and education. The research studies on safety culture were reported in the radiation industry by the Malaysian Agency for Nuclear in early 2008 (Mod Ali, 2008).

Other industries or sectors, which are concerned with safety culture, are healthcare sector (Abdullah, Spickett, and Rumchev, 2009; Ismail and Yunus, 2015; Jye, Hing, Peter, Bartholomew, and Senok, 2019), manufacturing industry (Kumar, Chelliah, Binti, and Amin, 2012; Amirah, Asma, Muda, and Mohd Amin, 2013; Amirah, Amin, and Muda, 2017; Ali, Yusof, and Adam, 2017; Hee,2014; Rohani, Shaharoun, and Haron, 2016; Amirah, Asma, Muda, and Nik Hanim, 2019), construction industry (Ismail, Harun, Ismail, and Zaimi. 2010; Saifullah and Ismail, 2012), shipping industry (Chan, Hamid and Mokhtar, 2019; Razali, Abdul, and Mohktar, 2019), education sector (Latti, Mittal, Chour, Patil,2013; Nor Kamilah, Balakrishnan, Mohad Nazri, Ahmad Rasdan, and Aryana 2019), and electronic industry (Abdullah, Othman, Osman, and Salahudin, 2016). The timeline for the safety culture studies in various industries in Malaysia is illustrated in Figure 2.10.

The key aim of safety culture studies in these industries is to minimise the risk of accidents and prevent them from occurring in the future. The poor management of safety issues in mining will have a great impact not only on government's economic loss, but also on the potential for life loss among miners. To date, no study has been conducted on safety culture in the mining industry in Malaysia, and there is a huge gap to be filled immediately. The necessity to have a clear framework on safety culture in the mining industry is demanding, especially in reducing the number of mining accidents and preventing great losses such as life loss, economic loss, and environmental issues. In addition, a positive safety culture will increase mine productivity. By conducting this research, it is an opportunity to investigate the influencing factors on safety culture in the mining industry and how safety-related outcomes can be improved in the future.

Table 2.6 Comparison on Safety Culture Studies from Various Industries

Type of industry	Country	Ref	Main factors of safety culture														
			Safety Attitude	Safety knowledge	Safety rules	Accident and incident	Reporting	Working Environment	Job Satisfaction	Management commitment	Safety commitment	Ownership of safety	Safety training	Safety communication	Reward	Safety investment	Workers competencies
Nuclear	Spain	López, Castro, Gracia, Peiró, Pietrantoni, and Hernández (2013)	/	/	/	/	/	/		/	/		/	/	/	/	/
	Finland and Sweden	Gotcheva Oedewald, Wahlström,Macchi, and Osvalder (2016)	/	/	/	/	/	/		/	/		/	/	/	/	/
	Netherlands	Mengolini and Debarberis (2012)	/	/		/	/	/		/	/		/	/			/
	Korea	Min, Bin, and Hyun (2018)	/	/		/	/	/		/	/	/	/	/			/
Construction	United Kingdom	Duryan, Smyth, Roberts, Rowlinson, and Sherratt, (2020)	/	/	/	/	/	/	/	/	/		/	/	/	/	/
	China	Zhang, Zhang W, and Xu (2019)	/	/	/	/	/	/		/	/		/	/			/
	Australia	Biggs Banks, Davey, and Freeman (2013)	/	/	/	/	/	/		/	/		/	/		/	/
Manufacturing	Saudi Arabia	Noweir, Alidrisi, Al-darrab, and Zytoon (2013)	/	/	/	/	/	/		/	/		/	/		/	/
	Sweden	Nordlöf, Wiitavaara, Winblad, Wijk, and Westerling, (2015)	/	/	/	/	/	/		/	/		/	/	/	/	/
	Iran	Ghahraman and Salminen (2019)	/	/	/					/	/		/	/			/
Mining	Ghana	Stemn et al., (2020)	/		/	/	/			/	/	/	/	/			
	China	Zhang, Fu, and et al.,(2020)	/	/	/			/		/	/	/	/	/		/	/

Table 2.6 Continued

Type of industry	Country	Ref	Safety Attitude	Safety knowledge	Safety rules	Accident and incident	Reporting	Working Environment	Job Satisfaction	Management commitment	Safety commitment	Ownership of safety	Safety training	Safety communication	Reward	Safety investment	Workers competencies
			Main factors of safety culture														
Oil and Gas	Sweden	Lööw and Nygren (2019)	/	/				/		/	/		/			/	/
	South Africa	Hussain, Cawood, and Ali (2018)		/			/						/	/			/
	Turkey	Düzgün and Leveson (2018)		/			/	/		/			/	/			
	Canada	Iqbal, Waheed, Haider, and Tesfamariam, (2019)	/	/	/	/	/	/		/	/	/	/	/		/	/
	Norway	Kongsvik et al. (2016)	/	/	/			/	/	/	/		/	/		/	/
	Norway	Antonsen, Nilsen, and Almkov (2017)	/	/	/	/	/	/					/	/	/		

Source: López, Castro et al. (2013), Gotcheva Oedewald et al. (2016), Mengolini and Debarberis (2012), Min, Bin, and Hyun (2018), Duryan, et al. (2020), Zhang et al. (2019), Biggs Banks et al. (2013), Noweir et al. (2013), Nordlöf et al. (2015), Ghahraman and Salminen (2019), Stemn et al., (2020), Zhang et al.(2020), Jiang et al. (2020), Bhattacharjee et al. (2020), Ajith et al. (2020), Lööw and Nygren (2019), Hussain et al. (2018), Düzgün and Leveson (2018), Iqbal et al. (2019), Kongsvik et al. (2016), Antonsen et al. (2017)

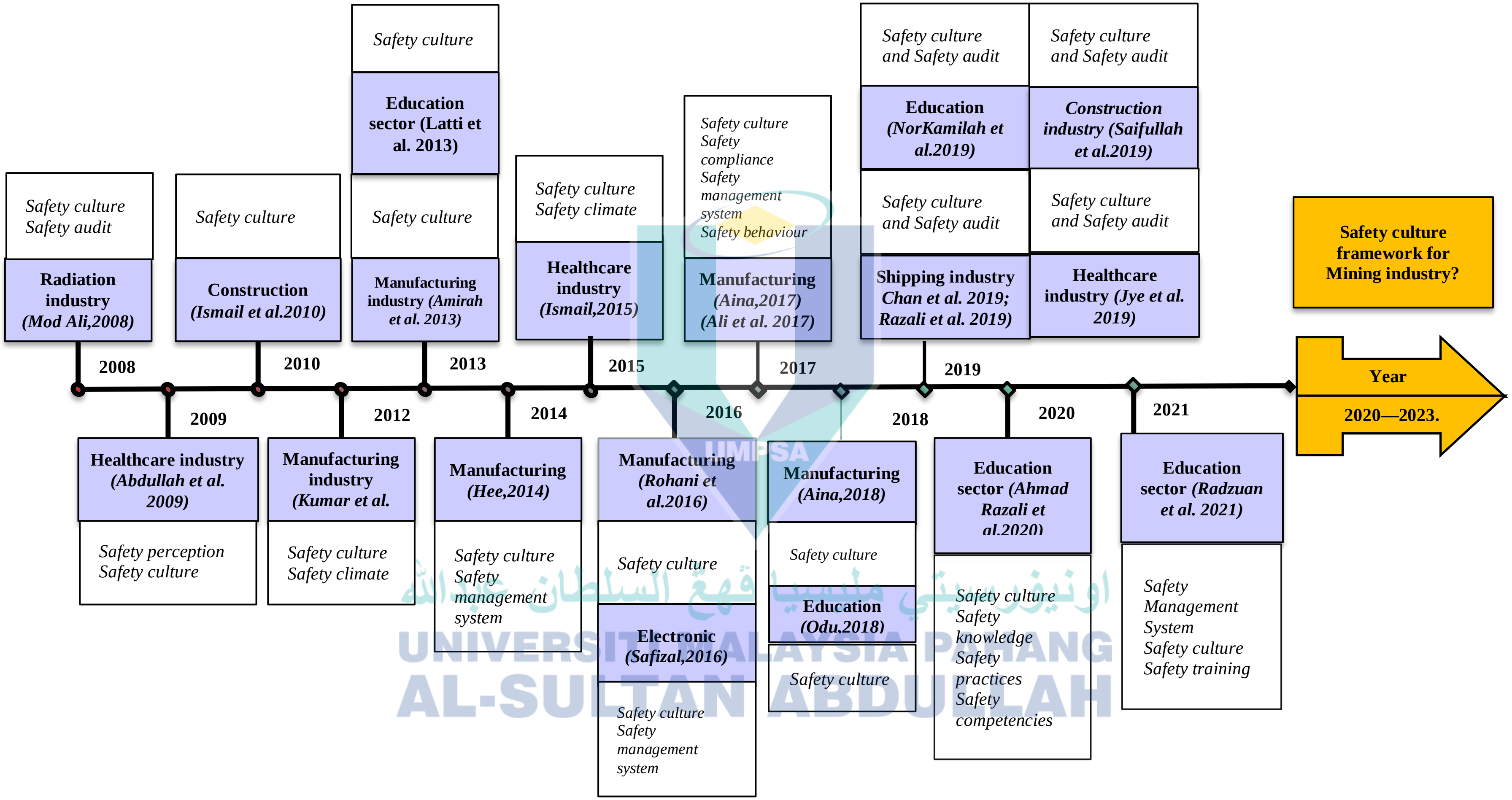


Figure 2.10 Timeline for safety culture studies from various sector in Malaysia in year 2008 to 2021

Source: Mod Ali (2008), Abdullah et al. (2009), Kumar et al. (2012), Ismail et al. (2010), Amirah et al. (2013), Ismail (2015), Aina (2017), Ali et al. (2017), Razali et al. (2019), NurKamilah et al.(2019) , Chan et al.(2019), Saifullah et al.(2019), Jye et al.(2019), Hee (2014), Rohani et al. (2016), Aina (2018) Safizal (2016), Ahmad Razali et al. (2020), Latti et al.(2013), Odu (2018).

2.2.6 Safety culture policies and regulations in mining industry from other countries

Examples of policies and regulations related to safety culture in mining industry from other countries are summarised in Table 2.7.

Table 2.7 Examples of policies and regulations related to safety culture in mining

Ref	Name of policy or regulations	Name of Safety culture framework	Objective	Important domain	Country
Cliff (2012)	The International Mining for Development Centre, Mining Occupational Health and Safety (OHS) Legislation	National Mine Safety Framework (NMSF) or Safety Culture Maturity Model Framework for Mining	To promote more sustainable use of minerals and energy resources in developing nations by assisting governments and civil society organisations through delivery of education and training, fellowships, research, and advice.	1. Risk management 2. Duty of care for employer and employee. 3. Implementation and monitoring 4. Stakeholder involvement	Australia
Foster and Hoult (2013)	Minerals Industry Risk Management (MIRM) Maturity	Safety Maturity Model for UK Coal mine	To assess the level of compliance and effectiveness of standards safety management system	1. Leadership and Accountability 2. Policy and commitment 3. Risk and change management Legal requirement Communication and consultation Training, competence and awareness Control of documents Operational controls	United Kingdom

Source: Cliff (2012), Foster and Hoult (2013)

2.3 Influencing Factors on Safety Culture in Mining: A Systematic Literature Review Approach

2.3.1 Introduction

This Systematic Literature Review (SLR) aims to investigate the influencing factor of safety culture by applying the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. A systematic review aims to comprehensively locate, search, and synthesise literature related to previous studies or research in a well-organised and transparent process, using replicable procedures throughout each step. Systematic reviews can also be called meta-narrative reviews (Wong, Greenhalgh, Westhorp, Buckingham, and Pawson, 2013) or mixed studies reviews. This process allows for multiple and diverse research designs to be reviewed in a single exercise (qualitative and quantitative). According to Wong et al. (2013), these reviews can embrace studies with different designs and concepts. It is also relevant to the statements of the researchers, supports research rigour, and helps promote the identification of gaps, trends, and needed directions for future studies. The main research question (Research Question 1) guiding this systematic review is: What are the influencing factors of safety culture studies that have been conducted in the mining industry? In fulfilling the empirical gaps, such domains and variables derived from this study could contribute to new knowledge for future scholarly work. Besides revealing important gaps in the literature, this SLR provides a reference for future studies related to the construction of a safety culture in the mining industry.

2.3.2 SLR methodology on safety culture in mining

The SLR process consists of four main steps: identification, screening, eligibility, and data abstraction and analysis (Moher, Liberati, Tetzlaff, and Altman, 2009). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used to establish the SLR on recent trends in safety culture studies, specifically in mining industries. PRISMA is well-known in environmental management studies, social sciences, safety studies, and many more. ScienceDirect, Scopus, Web of Science, and SpringerLink databases were chosen in the SLR study, and procedures from PRISMA were applied, such as the steps of the review process, including identification, screening, eligibility, and exclusion criteria. The data abstraction and analysis were included, as shown in Figure 2.11. Furthermore, three advantages of using PRISMA in the SLR (Sierra-Correa and Cantera Kintz, 2015) study are: (1) defining a clear research questions for a systematic research; (2) identifying both inclusion and exclusion criteria; and (3) being useful in examining the scientific literature databases within a period.

Four leading indexed databases used for this review were ScienceDirect, Scopus, Web of Science, and SpringerLink. These databases are considered the leading indexing systems for citations. Firstly, ScienceDirect consists of 3,500 academic journals and 34,000 e-books, and it has compiled over 12 million pieces of content for scientific and medical research. Secondly, Scopus is a well-known database that consists of various fields of study, including medicine, arts and humanities, social sciences, science, and technology. Meanwhile, The Web of Science (WoS) is the world's most trusted publisher-independent global citation database, which consists of over 171 million records from multidisciplinary fields. Fourthly, Springer Link contains more than 2,900 journals and 300,000 books, which offers many opportunities to explore the required subject matters related to researchers' needs. Because of their prominence, these four indexed databases were chosen, which is vital to ensuring the quality of the articles reviewed in this thesis.

2.3.3 Identification

The flow chart of the SLR study is shown in Figure 2.10. The first step in the systematic review process is identification, which was performed in December 2020. By using keywords and search strings of "safety culture" AND "mining", this process yielded a result of 850 articles from Science Direct, 1210 articles from Scopus databases, 210 articles from Web of Science (WoS), and 1730 articles from Springer Link databases, as shown in Figure 2.11. Figure 2.11 shows the flow chart of the SLR study (adapted from Moher et al., 2009).

2.3.4 Screening (Inclusion and exclusion criteria)

Screening is a process to include or exclude articles according to criteria determined by the researcher with the assistance of specific databases. In the screening process, eligibility, inclusion, and exclusion criteria were determined to find suitable articles to be included in the systematic review process. First, concerning the timeline, between the years 2016 to 2020 (5-year period) were selected based on the total number of related publications retrieved to be reviewed. The article journals with empirical data were chosen for second inclusion criteria. Meanwhile, other types of documents such as review articles, books, chapters in books, and conference proceedings, were excluded because they were not considered primary sources. The third criterion was that only journals that reported on safety culture in the mining industry were selected to ensure the quality of the reviewing process. The fourth criterion for the inclusion and exclusion criteria was language. All non-English language documents were excluded to avoid confusion and difficulties in the translation work in this paper, as shown in Table 2.8. After the identification process, out of 4000 articles to be screened, it resulted in 99 articles after the screening stage.

Table 2.8 Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Publication timeline	January 2016–December 2020	2015 and before
Document type	Journal (research articles)	Journals (systematic review), review papers, conference proceedings, chapters in book, book series, books
Type of industry	Safety culture in mining industry only	Exclude safety culture other than mining
Language	English	Non-English

2.3.5 Eligibility and duplication exclusion (Manual screening)

Eligibility is a process that includes or excludes articles manually according to the researcher's specific criteria. The articles retrieved were thoroughly reviewed in the process, excluding any that did not meet the criteria. Before the eligibility process was carried out, duplicate documents were removed first. 29 similar articles were excluded in both databases for the next phase, which left 70 documents for the eligibility process and were screened manually for literature focusing on mining accidents and criteria from the earlier screening processes (inclusion and exclusion criteria). The review managed to obtain 33 selected articles for SLR on safety culture in the mining industry.

2.3.6 Data abstraction and analysis

The fourth phase is data abstraction and analysis. The remaining articles were evaluated, reviewed, and analysed, and 33 selected articles (studies) were discussed in detail in this paper as tabulated in Tables 2.9 and 2.10. The reviews were based on specific studies that matched the research questions and focused on them. The studies were then extracted to identify relevant themes and sub-themes for the current study by reading the title, then the abstracts, and then throughout the full text of the articles (in-depth). An integrative review was conducted- a kind of review synthesising different types of research designs, such as qualitative, quantitative, and mixed methods (Whittemore & Knafl, 2005).

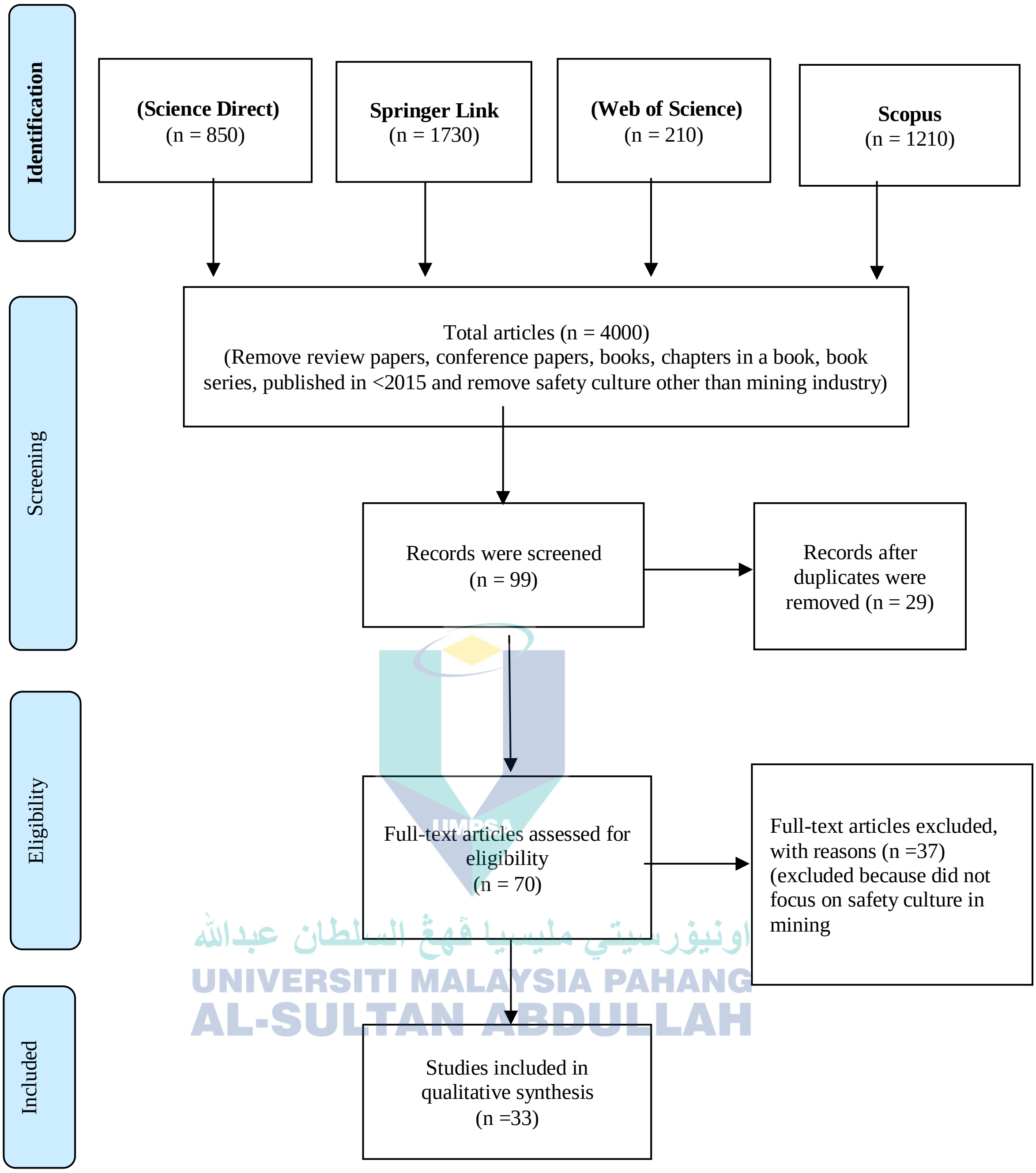
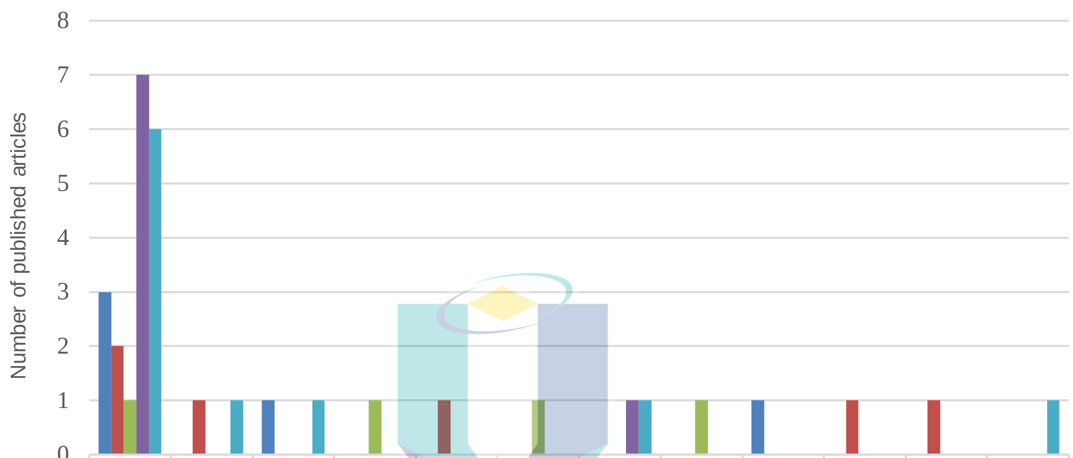


Figure 2.11 The flow chart of the SLR study

Source: Moher et al. (2009)

2.3.7 Main Findings

The review managed to obtain 33 selected articles from 12 countries, which are China, India, the USA, Ghana, Mongolia, Russia, Taiwan, Turkey, Brazil, Kenya, and South Africa, and Sweden on safety culture in the mining industry. Regarding the type of mines, 28 studies reported on safety culture in coal mines from China, India, the USA, Ghana, Mongolia, Russia, Taiwan, Turkey, and Brazil. Three studies reported on gold mines in Kenya and South Africa, and others reported in the USA and Sweden. Figure 2.11 shows the number of published articles on safety culture in the mining industry from twelve countries for the years 2016-2020. Overall, China was the leading country for publishing articles five years ago with 19 articles, followed by the USA (2 articles), Kenya (2 articles), India (2 articles), as well as Ghana, Mongolia, Russia, Taiwan, Turkey, Brazil, South Africa, and Sweden.



	China	USA	India	Sweden	Brazil	Turkey	Kenya	South Africa	Mongoli a	Rusia	Taiwan	Ghana
2016	3	0	1	0	0	0	0	0	1	0	0	0
2017	2	1	0	0	1	0	0	0	0	1	1	0
2018	1	0	0	1	0	1	0	1	0	0	0	0
2019	7	0	0	0	0	0	1	0	0	0	0	0
2020	6	1	1	0	0	0	1	0	0	0	0	1

Figure 2.12 SLR results on number of published articles on safety culture in year 2016 to 2020.

Source:

Furthermore, 12 articles were qualitative, 11 articles were fully quantitative, and 10 articles were mixed qualitative and quantitative. Table 2.9 shows the SLR results based on year, country, number of published articles, title of journal, and rankings. The details for each article in the SLR study are shown in Table 2.10. Most of the articles in the SLR study were obtained using the PRISMA approach (identification, screening, eligibility, abstraction analysis) which has an excellent reputation in the Journal Impact Quartile, as shown in Table 2.9.

Table 2.9 SLR results based on year, country, number of published articles, title of journal, and rankings.

Year	Country	No of published articles	Title of Journal	Journal Impact Quartile
2020	China	6	Process Safety and Environmental Protection	Q1
			Safety Science	Q1
			Resources Policy	Q1
			Safety and Health at Work	Q2
	USA	1	Journal of Safety Research	Q1
	Ghana	1	Safety Science	Q1
	India	1	Engineering Failure Analysis	Q1
	Kenya	1	Safety and Health at Work	Q2
2019	China	7	Resources Policy	Q1
			Safety Science	Q1
			Progress in Nuclear Energy	Q2
			Processes	Q2
			International Journal of Environmental Research and Public Health	Q1
	Kenya	1	Safety Science	Q1
	Sweden	1	Resources Policy	Q1
2018	China	1	Safety Science	Q1
	South Africa	1	Journal of the Southern African Institute of Mining and Metallurgy	Q4
	Turkey	1	Safety Science	Q1
2017	China	2	Safety Science	Q1
			Sustainability	Q2
	Russia	1	Ecology, Environment, and Conservation	Q2
	USA	1	International Journal of Mining Science and Technology	Q1
	Brazil	1	Gestao & Producao (Management and Operations Review)	Q3
	Taiwan	1	Sustainability	Q2
2016	China	3	Accident Analysis and Prevention	Q1
			Petroleum Science	Q1
			International Journal of Environmental Research and Public Health	Q1
	Mongolia	1	Journal of Cleaner Production	Q1
	India	1	International Journal of Disaster Risk Reduction	Q2

Source: Yorio et al. (2020), Miao et al. (2020), Stemn et al. (2020),Zhang et al. (2020), Fu, Xie, Jia, Tong, and Ge (2020), Rubin et al. (2020), Jiang et al. (2020), Bhattacharjee et al. (2020), Liu et al.(2020), Ajith et al. (2020), Ajith and Ghosh, (2019), Tong et al. (2019), Cao et al. (2019), Yu, et al. (2019), Jiang et al. (2019), Lööw and Nygren (2019), Qiao et al. (2019), Hussain et al. (2018), Wang et al. (2018), Düzgün and Leveson (2018), Nikulin and Nikulina (2017), Wu et al. (2017), Zhang et al. (2017), Komljenovic et al. (2017), Vassem et al. 2017), Yeh (2017), Zhang et al. (2016), Smith et al. (2016), Dash et al. (2016), Fu et al (2016), Zhang et al.(2016)

By applying a thematic analysis (Nowell et al., 2017), three main themes were developed: psychological dimension (four sub-themes), situational dimension (five sub-themes), and behavioural dimension (eight sub-themes). The results from the thematic analysis of the safety culture in mining study for each dimension are shown in Table 2.10. Based on SLR results, 47% reported on the behavioural dimension, followed by 29% on the situational dimension, and 24% on the psychological dimension. The influencing factors (sub-theme) for each dimension are shown in Figure 2.13. It shows that the safety culture is a continuous commitment and complements each other in creating a healthy safety culture in the mining industry.

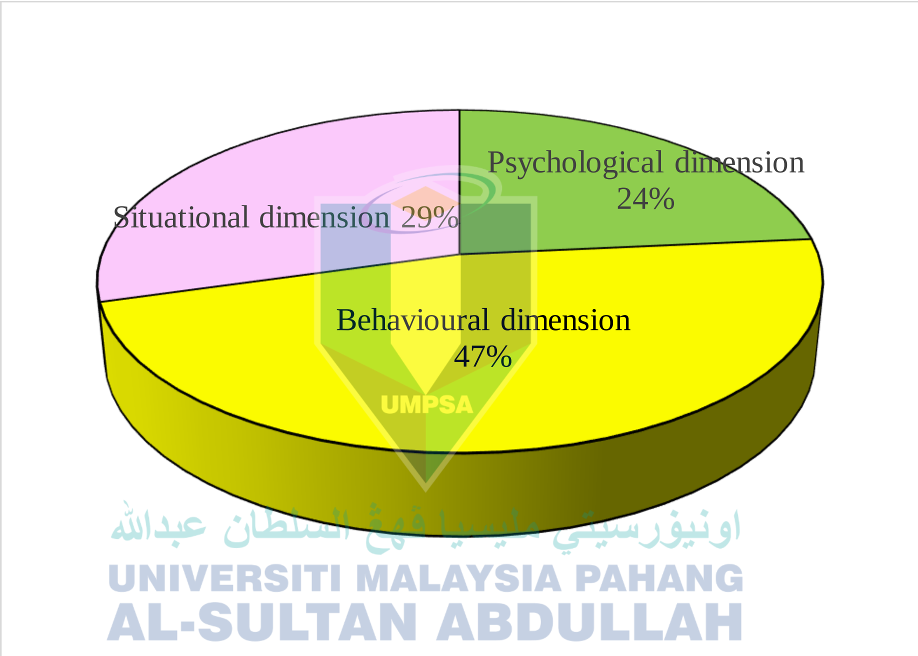


Figure 2.13 Percentage of safety culture based SLR results

Table 2.10 SLR results on safety culture in mining industry from 2016 to 2020

Ref	Year	Type of study	Type of mine	Country	Psychological Dimension			Situational Dimension							Behavioural Dimension						
					SA	PI	SK	PR	SR	AI	RE	WE	JS	MC	SC	OS	ST	CO	RR	SI	WC
Yorio, Haas, Bell, Moore, and Greenawald (2020)	2020	QN	24,910 mines	USA						/	/			/			/	/			
Miao et al. (2020)	2020	MM	coal mine	China			/			/		/					/				/
Stemn et al. (2020)	2020	QN	coal mine	Ghana	/				/	/	/			/	/	/	/	/			
Zhang, Fu, and et al. (2020)	2020	MM	coal mine	China	/		/		/			/		/	/	/	/	/		/	/
Fu, Xie, Jia, Tong, and Ge (2020)	2020	QN	coal mine	China	/		/		/	/	/	/		/	/		/				/
Rubin et al. (2020)	2020	QN	coal mine	China	/	/	/	/	/	/	/	/	/	/			/	/	/		
Jiang et al. (2020)	2020	QN	coal mine	China		/	/		/	/		/		/	/	/	/		/	/	
Bhattacharjee et al. (2020)	2020	QL	coal mine	India			/	/	/	/		/		/	/		/	/			/
Liu, Dou, and Meng (2020)	2020	QL	coal mine	China			/	/						/	/						
Ajith et al. (2020)	2020	QN	gold mine	Kenya			/							/		/	/				
Ajith and Ghosh, (2019)	2019	QN	gold mine	Kenya					/			/	/	/							
Tong et al. (2019)	2019	MM	coal mine	China	/		/					/	/	/	/		/	/			/
Cao, Yu, Zhou, Wang, and Li (2019)	2019	MM	coal mine	China			/	/	/	/		/		/	/		/	/			

Table 2.10 Continued

Ref	Year	Type of study	Type of mine	Country	Psychological Dimension			Situational Dimension							Behavioural Dimension						
					SA	PI	SK	PR	SR	AI	RE	WE	JS	MC	SC	OS	ST	CO	RR	SI	WC
Yu, Cao, Xie, Qu, and Zhou (2019)	2019	MM	coal mine	China	/		/					/		/			/	/			/
Jiang et al. (2019)	2019	QN	coal mine	China	/		/							/	/	/					
Lööw and Nygren (2019)	2019	QL	Not mentioned	Sweden	/		/					/		/	/		/			/	/
Qiao et al. (2019)	2019	QL	coal mine	China						/	/			/			/	/			/
Hussain et al. (2018)	2018	QN	gold mine	South Africa.			/				/						/	/			/
Wang et al. (2018)	2018	MM	coal mine	China	/		/		/			/	/	/	/	/	/	/	/		/
Düzgün and Leveson (2018)	2018	QL	coal mine	Turkey			/	/			/	/		/			/	/			
Nikulin and Nikulina (2017)	2017	QL	coal mine	Rusia				/				/	/	/	/			/		/	
Wu et al. (2017)	2017	MM	coal mine	China	/			/		/		/	/	/	/	/					
Zhang, Shi, and Wu (2017)	2017	QN	coal mine	China			/	/	/					/	/		/				/
Komljenovic, Loiselle, and Kumral (2017)	2017	QL	coal mine	USA								/		/	/		/				
Vassem Fortunato, Bastos, and Balassiano (2017)	2017	QN	coal mine	Brazil			/							/	/			/			

Table 2.10 Continued

Ref	Year	Type of study	Type of mine	Country	Psychological Dimension				Situational Dimension						Behavioural Dimension						
					SA	PI	SK	PR	SR	AI	RE	WE	JS	MC	SC	OS	ST	CO	RR	SI	WC
Yeh (2017)	2017	QN	Not mentioned	Taiwan						/		/					/				
Zhang, Shao et al. (2016)	2016	QL	coal mine	China			/		/					/							/
Smith, Ali, Bofinger, and Collins (2016)	2016	QN	coal mine	Mongolia					/			/		/							
Dash et al. (2016)	2016	QN	coal mine	India	/		/				/			/	/			/	/		
Fu, Cao, Zhao, and Xiang (2016)	2016	QN	coal mine	China	/		/		/			/		/			/	/			/
Zhang, Chen, Fu, Yan, and Kim (2016)	2016	QN	coal mine	China					/			/		/	/	/	/	/		/	

Psychological Dimension	Situational Dimension	Behavioural Dimension	Type of Study
SA= Safety Attitude	SR=Safety rules	MC= Management commitment	QL= qualitative study
PI= Peer influence	AI = accident and incident	SC= Safety commitment	QN= quantitative study
SK= Safety Knowledge	RE=Reporting	OS = Ownership of Safety	MM= mixed mode study
PR = Perception of Risk	WE = Working Environment	ST= Safety Training	
	JS = Job Satisfaction	CO= Safety communication	
		RR= Reward and recognition	
		SI= Safety investment	
		WC= Worker's competencies	

Sources: Yorio et al. (2020), Miao et al. (2020), Stemn et al. (2020),Zhang et al. (2020), Fu, Xie, Jia, Tong, and Ge (2020), Rubin et al. (2020), Jiang et al. (2020), Bhattacharjee et al. (2020), Liu et al.(2020), Ajith et al. (2020), Ajith and Ghosh, (2019), Tong et al. (2019), Cao et al. (2019), Yu, et al. (2019), Jiang et al. (2019), Lööw and Nygren (2019), Qiao et al. (2019), Hussain et al. (2018), Wang et al. (2018), Düzgün and Leveson (2018), Nikulin and Nikulina (2017), Wu et al. (2017), Zhang et al. (2017), Komljenovic et al. (2017), Vassem et al. (2017), Yeh (2017), Zhang et al. (2016), Smith et al. (2016), Dash et al. (2016), Fu et al (2016), Zhang et al.(2016)

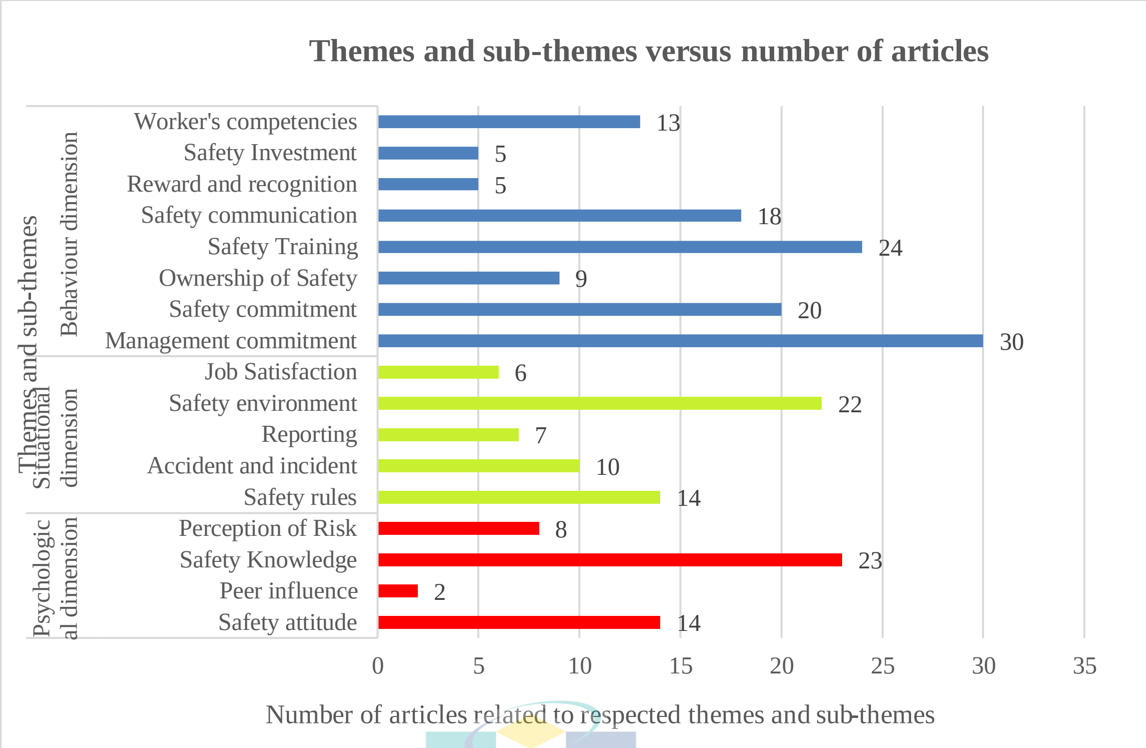


Figure 2.14 SLR results on influencing factors of safety culture for each dimension (each article has more than one sub-theme)

Sources: Yorio et al. (2020), Miao et al. (2020), Stemn et al. (2020),Zhang et al. (2020), Fu, Xie, Jia, Tong, and Ge (2020), Rubin et al. (2020), Jiang et al. (2020), Bhattacharjee et al. (2020), Liu et al.(2020), Ajith et al. (2020), Ajith and Ghosh, (2019), Tong et al. (2019), Cao et al. (2019), Yu, et al. (2019), Jiang et al. (2019), Lööw and Nygren (2019), Qiao et al. (2019), Hussain et al. (2018), Wang et al. (2018), Düzgün and Leveson (2018), Nikulin and Nikulina (2017), Wu et al. (2017), Zhang et al. (2017), Komljenovic et al. (2017), Vassem et al. 2017), Yeh (2017), Zhang et al. (2016), Smith et al. (2016), Dash et al. (2016), Fu et al (2016), Zhang et al.(2016)

2.3.8 Psychological Dimension for Safety Culture

The main reason to understand the safety culture is to prevent mine accidents from occurring in the mining industry. Based on the SLR study, three main dimensions were generated: psychological (24%), situational (29%), and behavioural (47%), as shown in Figure 2.14. Based on thematic analysis, four sub-themes were developed: safety attitude (13 studies), peer influence (2 studies), safety knowledge (16 studies), and perception of risk (5 studies).

2.3.8.1 Safety attitude

Attitude refers to *"a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour"* (Eagly and Chaiken, 1993), and safety attitudes for miners focus on their psychological orientation towards safe culture, procedures, and accident prevention (Hu, Rahmandad, Smith-Jackson, and Winchester, 2011; Wang et al. 2018). Another definition of safety attitude is the reflection of employees' beliefs and emotions concerning safety policies, procedures, and practises (Li et al., 2019). A total of 13 studies out of 33 were reported on safety attitude as a domain or sub-theme for safety culture in the mining industry. For coal mines in China, the safety attitude was reported by Rubin et al. (2020), Zhang, Fu, and Hao. (2020), Tong et al. (2019), Wang and Wu (2019), Fu et al. (2019), Yu et al. (2019), Jiang et al. (2019), Wang et al. (2018), Wu et al. (2017), and Zhang et al. (2016). For example, Rubin et al. (2020) conducted a survey on 233 miners and found that the main constraint on miners' ability to inculcate a safety culture was a lack of safety motivation. This is supported by Wu et al. (2017). He investigated 725 coal miners and concluded that 84% miners have a low educational background, which leads to a fatalist attitude and low self-motivation among them. Zhang et al. (2020) also concluded that ignored safety laws and regulations are examples of bad safety attitudes among miners.

Furthermore, poor physiological status and bad safety habits were examples of safety attitudes among 27 coal mining enterprises, as reported by Jiang et al. (2019). In Ghana, Stemn et al. (2020) conducted a safety culture maturity survey on 9767 mine workers and found that the main constraint to implementing safety culture was a lack of care and respect among themselves. In Sweden, safety attitude was reported by Lööw and Nygren (2019). They analysed the safety-related developments in the Swedish mining industry over a 30-year period, from the 1980s to the 2010s. One of the difficulties in implementing a safety culture was due to ignorance about safety among miners (Lööw and Nygren, 2019). Moreover, the culture of denial or normalisation of pre-warning signals among miners was a major contributory factor to all mine disasters that occurred in India (Dash et al., 2016).

2.3.8.2 Peer influence

The second sub-theme is peer influence, which is established as one of the domains of safety culture in the mining industry. Rubin et al. (2020) concluded that fostering a positive safety culture was highly dependent on peer influence and commitment. Bad peer influence among miners would lead to mining disasters. This finding was supported by a survey of 233 coal miners within a period of 10 months. Jiang et al. (2020) conducted a survey on 82 coal mine enterprises and concluded that peers or colleagues had a great influence on fostering a safety culture among miners.

2.3.8.3 Safety knowledge

Safety knowledge is a vital domain in safety culture studies, with a total of 16 studies out of 33 reported it as a domain of safety culture in the mining industry. The success of safety culture in an organisation highly depends on the adequate knowledge of mine workers. A total of 16 studies out of 35 reported safety knowledge as a domain for safety culture in preventing mine accidents. The importance of safety knowledge was reported in coal mines in China (Miao et al.2020; Zhang et al. 2020; Jiang et al. 2020; Wang and Wu, 2019; Fu et al. 2019; Yu et al. 2019; Jiang et al., 2019; Lööw and Nygren, 2019; Wang et al., 2018; Zhang et al., 2016; Fu et al.2016), Turkey (Düzgün & Leveson, 2018), Brazil (Vassem et al.2017), and India (Dash et al.2016). The concern about safety knowledge was also reported in gold mines by Ajith et al. (2020) in Kenya and Hussain et al. (2018) in South Africa. The safety knowledge reported by researchers included knowledge on production and production equipment, machine handling, safety awareness, knowledge on skills and competencies, and training on at-scene self-rescue and self-protection.

2.3.8.4 Perception of risk

The fourth subtheme is perception of risk, with five studies reported. The great perception of the potential risk of accidents is important to prevent mine accidents. This sub-theme or domain is important in safety culture in China (Rubin et al., 2020; Wu et al., 2017; Zhang et al., 2017), Turkey (Düzgün & Leveson, 2018), and Russia (Nikulin and Nikulina, 2017). For example, Rubin et al. (2020) stressed the various risk concepts such as level of on-the-job risk, control over risk, risk awareness, and risk assessment ability, to prevent the occurrence of mine accidents. They conducted the study in a coal mine and found that 42.92% of participants indicated that the safety risks that they had taken over the past two months had no chance of injuring themselves, others, or equipment. Wu et al. (2017) conducted a study on 725 coal miners and found a lack of risk consciousness among coal miners about the potential risks of their work environment, which results in a deficiency of risk-related emotions. This directly led to mine accidents. Moreover, Nukulin et al. (2017) conducted a survey in a coal mine in

Russia and found that risk assessments involving employees were an important domain in safety culture to prevent mine accidents. The analysis of the Soma Mine Disaster (SMD), which occurred due to a fire in the underground coal mine and caused 301 fatalities in 2014 due to improper decision-making and risk perception, was reported as one of the reasons for the accident (Düzgün & Leveson, 2018).

2.3.9 Situational Dimension

Situational dimension was created as the second theme, which refers to the working environment of the mine itself as a response to the safety culture in the mining industry. Five sub-themes or domains were established under the situational dimension theme, such as safety rules (10 studies), accidents and incidents (4 studies), reporting (4 studies), the safety environment (17 studies), and job satisfaction (5 studies).

2.3.9.1 Safety Rules

The first sub-theme is safety rules. A total of 11 studies out of 33 were reported on the safety rules as sub-themes for safety culture in the mining industry. The importance of safety rules as influencing factors for safety culture was discussed in coal mines in China (Zhang et al. 2020; Rubin et al., 2020; Jiang et al., 2020; Fu et al., 2019; Zhang et al., 2016; Fu et al., 2016), Ghana (Stemn et al., 2020), Mongolia (Smith et al., 2016), and a gold mine in Kenya (Ajith and Ghosh, 2019). Furthermore, the examples of safety rules in a mine site are safety regulations, understanding of the role of the safety sector, implementation of safety systems, understanding of the types of safety checks and safety expectations, and having emergency response capabilities. These are the examples of safety rules highlighted by Jiang et al. (2020).

However, the objective of a safety culture is difficult to achieve due to the ignorance of mine workers. For example, Zhang et al. (2020) concluded safety rules' breaches among miners, such as an imperfect emergency management system, failure to implement a safety production responsibility system, illegal risk-taking operations, failure to comply with the Safety Work Law, Coal Mine Safety Regulations, Rules for Management of Dust Prevention, Gas Prevention, Fire Prevention etc., illegal cross-border mining, and illegal use of equipment and processes prohibited by the State. Rubin et al. (2020) also mentioned that poor safety norms at the mine sites have a high tendency of the safety rules to be broken. Fu et al. (2016) stressed that ignorance of safety rules due to a lack of knowledge led to mine disasters. It was supported by Zhang, Chen et al. (2016) and Ajith and Ghosh (2019). Poor safety regulations and systems for mine production, poor management and supervision, and ignorance of safety rules are potential contributors to mine disasters.

2.3.9.2 Accidents and incidents

The second sub-theme is accidents and incidents, and four studies were reported on it. Miao et al. (2020) stated the importance of understanding the potential of accidents and incidents in preventing coal mine accidents in China. This was supported by Rubin et al. (2020) and Jiang et al. (2020). The lesson learned from the previous mine accidents is crucial for future studies and to ensure the same mistake does not occur again. They analysed the data based on 828 employees of four large-scale gold mines and concluded that the mines with lower incidence rates consistently had higher safety culture maturity scores compared to mines with a higher incidence rate (Stemn et al., 2020). Learning from incidents includes acquiring information, reporting investigations and analyses, planning corrective actions, as well as implementing and monitoring them to ensure that mine accidents can be prevented.

2.3.9.3 Reporting

The next sub-theme of safety culture is reporting on accidents, misconduct, or any breach of safety rules, as reported in coal mines in China (Rubin et al., 2020), Ghana (Stemn et al., 2020), India (Dash et al., 2016), and South Africa (Hussain et al., 2018). For example, Stemn et al. (2020) conducted research that involved collecting safety culture and incident rate information from four large-scale coal mines in Ghana. The four mines altogether employed 9767 workers and were selected to enable a comparison of their incidence rates and self-reported safety culture maturity scores to determine if any association exists between their incidence rate and safety culture maturity level. As a result, Monitoring, Audit, and Review were created to provide a proper platform for reporting any accident or misconduct behaviour. In contrast, coal mine reports by Rubin et al. (2020) revealed that some miners may have failed to report some accidents and near misses because they lacked trust in the anonymity and/or confidentiality of their responses and felt that they may receive a penalty for reporting their accidents. Moreover, inventory records should be kept for all facilities, along with personal and work phone information, because these should be available for rescue efforts, as reported by Hussain et al. (2018). Flaws in system auditing were reported by Dash et al. (2016) as one of the reasons for poor reporting of coal mines in India.

2.3.9.4 Safety environment

A good safety environment or safe working place is important to ensure the mine workers have high motivation to perform their job and foster a good safety culture. However, the poor safety environment will demotivate mine workers and affect the company's productivity. Physical environment includes all environmental factors that can affect production safety, which mainly include ventilation, lighting, temperature, humidity, noise, dust, hazardous gases, and vibration. The combined action of these factors can affect the miners' physical and psychological conditions, while an undesirable physical environment can induce unsafe behaviours (Wang et al.2018). A total of 18 studies out of 33 reported the safety environment as the fifth sub-theme. The summary of safety environment issues reported by 18 researchers is in Table 2.11.

Table 2.11 Key findings related to safety environment

Country/ Type of mine	**Key findings related to safety environment**	**Ref**
China / Coal mine	• Not enough equipment allocation funds • No advanced technology and safety facilities	Miao et al. (2020)
	• Imperfect work conditions	Zhang et al. (2020)
	• Adequate number of mine workers • Work team pressure	Rubin et al. (2020)
	• Satisfaction on facilities	Jiang et al. (2020)
	• Poor working conditions	Wang et al. (2019)
	• Satisfaction of facilities	Fu et al. (2019)
	• Poor physical environment at workplace	Yu et al. (2019)
	• Poor physical environment at workplace	Wang et al. (2018)
Turkey/ Coal mine	• Ventilation problems • Insufficient personal safety equipment • Stress due to increased production • Subcontracting the mining operations • Insufficient precautions for methane explosion • Inadequate escape routes	Düzgün et al. (2018)

Table 2.11 Continued

Country/ Type of mine	Key findings related to safety environment	Ref
Rusia/ Coal mine	• Maintaining workplace safety • A favourable climate • Well-developed infrastructure	Nikulin and Nikulina (2017)
USA/ Coal mine	• Poor working area	Komljenovic et al. (2017)
Mongolia/ Coal mine	• The negative impacts of temporary living arrangements including crowded living spaces, • Unsanitary conditions, • Lack of facilities services • Social conflicts among miners and between miners and surrounding communities, mining companies, and authorities	Smith et al. (2016)
Kenya/ Gold mine	• Poor working conditions	Ajith and Ghosh, (2019)
Sweden/Others	• Lack of safety at workplace • Poor physical work environment • Psychosocial work environment	Lööw et al. (2019)

Source: Miao et al. (2020), Zhang et al. (2020), Rubin et al. (2020). Jiang et al. (2020), Wang et al. (2019), Fu et al. (2019), Yu et al. (2019), Wang et al. (2018), Düzgün et al. (2018), Nikulin and Nikulina (2017), Komljenovic et al. (2017), Smith et al. (2016), Ajith and Ghosh, (2019), Lööw et al. (2019)

2.3.9.5 Job satisfaction

One of the factors influencing safety culture is job satisfaction, as reported in coal mines in China (Miao et al. 2020; Rubin et al. 2020; Fu, Zhao, Hao, and Wu, 2019; Wu et al.2017), coal mines in Russia (Nikulin and Nikulina, 2017), and gold mines in Kenya (Ajith and Ghosh, 2019). The job dissatisfaction and job stress caused by poor safety culture among miners in artisanal and small mine (ASM) gold mine operations were reported by Ajith and Ghosh (2019). This is supported by Wu et al. (2017). They revealed that recent research on work pressure has a significant influence on an employee's safety behaviour and leads to a poor safety culture. Moreover, job performance and job stability are important to miners (Rubin et al., 2020) and also improve coal miner job status in the society (Nikulin and Nikulina, 2017).

2.3.10 Behavioural Dimension

The third theme is the behavioural dimension, with eight sub-themes generated including management commitment. Safety behaviour is defined as individuals' behaviours to promote health and safety of a working environment (Li et al. 2019). Eight sub-themes were established under the situational dimension theme, such as management commitment (26 studies), safety commitment (14 studies), ownership of safety (9 studies), safety training (18 studies), safety communication (13 studies), reward and recognition (5 studies), safety investment (5 studies), and worker's competencies (9 studies).

2.3.10.1 Management commitment

Management commitment in this SLR study refers to the commitment of the mine owner to foster a safety culture among mine employees. Most SLR articles mentioned management commitment as a key influencing factor in safety culture in coal mines, such as in China (Zhang et al., 2020; Rubin et al., 2020; Jiang et al., 2020; Wang et al., 2019; Qiao et al., 2019; Fu et al., 2019; Yu et al., 2019; Jiang et al., 2019; Wang et al., 2018; Wu et al., 2017; Zhang et al., 2016; Lie et al., 2020; Wu et al., 2017), India (Bhattacharjee et al., 2020; Dash et al., 2016), Turkey (Düzgün & Leveson, 2018), Ghana (Stemn et al., 2020), Rusia (Nikulin and Nikulina, 2017), Mongolia (Smith et al., 2016), Brazil (Vassem et al., 2017), and gold mines in Kenya (Ajith et al., 2020; Ajith et al., 2019), as well as in Sweden (Lööw and Nygren, 2019).

For example, Yorio et al. (2020) analysed 24,910 mines (4511 coal mines (18.1%); 770 metal mines (3.1%); 1155 non-metal mines (4.6%); 6930 stone mines (27.8%); and 11,544 sand and gravel mines (46.3%) in USA. He revealed that 469 accidents and fatalities occurred due to weaknesses in organisational safety and management commitment towards handling safety issues among mine workers. Zhang et al. (2020) revealed that poor safety culture reflects the weaknesses of management's commitment to safety issues. They analysed 67 typical major accidents in coal mines and found deficiencies in safety culture due to ignored safety laws and regulations (frequency is 100 %), unrealised safety priorities (100%), the limited role of functional departments (86.6 %), and insufficient attention to safety education for special operation personnel and mining workers (80.6%). This is supported by Qiao et al. (2019). They stressed that the root cause of coal mine accidents was due to insufficient attention to safety management and failure to form a preventive safety culture, resulting in risk loopholes in coal mining enterprises. Moreover, good leadership and coordination abilities are key elements for management commitment to construct a good safety culture (Düzgün & Leveson, 2018).

According to Ajith et al. (2020), they found that gold mine workers in Kenya have a low opinion about mine management and the owner's commitment to safety, which reflects the ignorance of the management to prioritise safety issues in mine operations, as well as mine employees. Another study conducted on 288 coal mine workers in Brazil proved that factors related to the culture of safety are organisational learning, information, and commitment (Vassem et al., 2017). In Mongolia, the management commitment highlighted (1) clear guidance materials to assist small miners in managing health and safety; (2) the development of a Safety Management System for small-scale mines; (3) the formal identification of the inspection requirements for small-scale mines; and (4) the development of assessment tools to allow efficient inspection processes (Smith et al., 2016).

2.3.10.2 Safety commitment

The second sub-theme is safety commitment, which refers to individuals' commitment (mine owner and mine worker) towards safety to ensure the mine site is a safe place to work. This influencing factor of safety culture has been studied in coal mines in China (Zhang et al. 2020; Jiang et al.2020; Wu et al. 2017; Wang et al. 2019; Fu et al. 2019; Wang et al. 2018; Zhang et al., 2016), Russia (Nikulin and Nikulina, 2017), Ghana (Stemn et al. 2020), USA (Komljenovic et al. 2017), Brazil (Vassem et al. 2017), India (Dash et al., 2016), and Sweden (Lööw et al. 2019) The characteristics of safety commitments were studied by Zhang et al. (2020) on 67 coal mine accidents, and they concluded that the mine accidents caused by poor safety management were due to unrealised safety priorities, flaws in management actions towards safety, passive safety compliance and participation of employees, and imperfect work conditions. Moreover, quantitative measurement data on safety culture obtained by the research team in the last ten years in coal mines in China showed that the safety commitment of mine enterprises is low and needs to be improved (Jiang et al. 2020).

Another study conducted by Wu et al. (2017) examined four dimensions such as management safety commitment, team safety climate, fatalism, and work pressure on 725 coal miners. He found these four dimensions important to constructing a good safety culture in coal mines. In Russia, the focus of the study on safety commitment conducted by Nikulin et al. (2017) on the Obukhovskaya coal mine is to minimise industrial injuries through (1) the implementation of new equipment and new technologies, (2) safety culture promotion as a viable method of reducing industrial injuries and occupational morbidity, and (3) priority measures of proactive response to any identified safety violations.

2.3.10.3 Ownership of Safety

Ownership of safety refers to an employee's sense of responsibility for and empowerment towards safety (Zhang et al. 2020). These include lack of compliance behaviour and responsibility, violation operation, not a wearing self-rescuer, underground smoking, gas inspector leaving the post without authorisation, violation operation without opening the ventilator. This ownership of safety was highlighted in coal mines in China (Zhang et al. 2020; Jiang et al. 2020; Fu et al.2019; Jiang et al. 2019; Wang et al. 2018; Wu et al.2017; Zhang et al. 2016) and Ghana (Stemn et al. 2020), as well as a gold mine in Kenya (Ajith et al. 2020). Lack of compliance behaviour and responsibility among coal mine employees was an influencing factor in the safety culture study, as reported by Zhang et al. 2020). This finding was agreed upon by Jiang et al. (2020) who stated that the responsibility of work safety contributes to a safety culture. Ajith et al. (2020) examined the safety culture maturity level of miners in Ghana and explored the relationship between cultural maturity and accident rates among 828 employees of four large-scale gold mines. He found that employee involvement and coaching were important in the safety culture study.

2.3.10.4 Safety training

Many researchers agreed that safety training is a critical influencing factor in safety culture. Many researchers conducted studies on safety culture in coal mines in China (Miao et al. 2020; Zhang et al. 2020; Rubin et al. 2020; Jiang et al. 2020; Wang et al. 2019; Fu et al. 2019; Yu et al. 2019; Wang et al. 2018; Wu et al. 2017; Zhang et al. 2020; Zhang et al. 2016), Turkey (Düzgün & Leveson, 2018), Ghana (Stemn et al. 2020), USA (Komljenovic et al. 2017), as well as gold mines in Kenya (Ajith et al. 2020) and South Africa (Hussain et al. 2018). According to Miao et al. (2020), safety training and education will create a safety culture atmosphere inside coal enterprises. and directly, the employees themselves will improve their own safety awareness. A study conducted by Zhang et al. (2020) on coal mines in China revealed that 80.6% of the mine workers had poor educational backgrounds, lack of systematic job training, and inappropriate training contents which led to deficiencies in safety culture. Furthermore, Cao et al. (2019) stressed the importance of safety training to create a safe atmosphere that has a direct positive impact on miners. Düzgün and Leveson. (2018) also revealed that inadequate safety culture led to mine disasters due to poor training of coal miners in Turkey. Establishing a safe learning mode and encouraging employees to learn safety knowledge and skills through adequate safety training directly contribute to the development of an in-house safety culture (Yu et al. 2019; Zhang, Chen, and et al. 2016).

2.3.10.5 Safety communication

A total of 13 out of 33 studies reported safety communication. Good communication leads to a mutual understanding between mine workers and the organisation, and the information can be disseminated more effectively and efficiently. Communication refers to the exchange of information and thoughts between the superiors and the subordinates, as well as between workers at the same level, in order to eliminate disorders in production safety and enhance production safety efficiency. Safety communication was agreed upon by previous researchers as the main criteria for the construction of a safety culture in the mining industry. The issues of safety communication are summarised in Table 2.12.

Table 2.12 Safety communication issues

Ref	Country /type of mine	Safety communication issues
Zhang, Fu, and et al. (2020)	China/coal mine	i. Missing report ii. Imperfect system of hazard reports accident early warning report iii. Emergency process and production site issue report and feedback iv. Failure to perform safety duties and safety

Table 2.12 Continued

Ref	Country /type of mine	Safety communication issues
Stemn et al. (2020)	China/coal mine	i. Required safety communication through HSE meetings
Wang et al. (2019)	China/coal mine	i. Participation in safety-related ii. Safety meeting and activity iii. Safety report iv. Safety advice
Yu et al. (2019)	China/coal mine	i. Establishing safety information communication and communication procedures.
Zhang, Shao et al. (2016)	China/coal mine	i. Lack of coordination among workers
Rubin et al. (2020)	China/coal mine	i. Required clarity and accessibility of safety systems,
Hussain et al. (2018)	China/coal mine	ii. The problem on channelling the information
Wang et al. (2018)	China/coal mine	i. Encourage communication through multiple channels, such as e-mail, forum, work report and communication corner, ii. Have a good organizational structure to ensure smooth communication on safety concerns
Düzgün & Leveson (2018)	Turkey/coal mine	i. Provide adequate communication system and coordination between the various decision-makers in the mine, ii. Develop codes and standards for safe mining practice iii. Provide a channel for coordination and communication for emergencies
Nikulin and Nikulina (2017)	Russia/coal mine	i. Required a feedback channel between employees and company management
Vassem et al. (2017)	Brazil/coal mine	ii. The existence of information channels, and the effectiveness of this communication
Zhang, Chen, and et al. (2016)	China/coal mine	i. Promote the transformation and restructuring of coal enterprises for ease communication
Dash et al. (2016)	India/coal mine	ii. Engineering, design and maintenance flaws iii. Failure to heed warning signs
Dash et al. (2016)	India/coal mine	i. Failures in regulatory oversight ii. Ignored worker/supervisor's instructions iii. Poor worker/management communication and trust iv. Flaws in emergency and rescue procedures

Source: Zhang et al. (2020), Stemn et al. (2020), Wang et al. (2019), Yu et al. (2019), Zhang, Shao et al. (2016), Rubin et al. (2020), Hussain et al. (2018), Wang et al. (2018), Düzgün & Leveson (2018), Nikulin and Nikulina (2017), Vassem et al. (2017), Zhang et al. (2016), Dash et al. (2016)

2.3.10.6 Reward and recognition

Reward and recognition such as bonuses and salary increments were reported in China (Rubin et al. 2020; Jiang et al. 2020; Fu et al. 2019; Wang et al. 2018) and India's coal mines (Dash et al. 2016). The reward can increase the motivation of miners, increase the company's productivity, and provide a good safety culture environment among mine workers.

2.3.10.7 Safety Investment

The next sub-theme is safety investment, which refers to the investments on employees, technologies, faculties, and tools that are involved in production safety (Wang et al., 2018). Safety investment was agreed to be one of the influencing factors in constructing a good safety culture, as reported by Zhang et al. (2020), Jiang et al. (2020), and Zhang, Chen, and et al. (2016) in coal mines in China, in Russia by Nikulin and Nikulina (2017), including Sweden by Lööw et al. (2019).

2.3.10.8 Worker's Competencies

Skilful and competent mine workers are important to ensure a sustainable mine operation, as well as human capital development. This sub-theme was reported as one of the influencing factors in constructing a good safety culture in coal mines in China (Miao et al. 2020; Zhang et al. 2020; Yu et al.2019; Fu et al. 2016; Zhang et al. 2016), in Turkey (Düzgün & Leveson, 2018), India (Bhattacharjee et al. 2020), and gold mines in South Africa (Hussain et al. 2018). According to Miao et al. (2020), the higher the professional and cultural level of employees, the less likely they are to choose unsafe behaviours. The good working conditions and psychological needs of safe operation possessed by highly educated personnel can also significantly improve the safety and a lack efficiency of the production and operation processes of coal enterprises. Poor vocational skills and lack of operational capability for special equipment due to a low level of education and training also contribute to major mine accidents in China (Zhang et al. 2020) and Sweden (Lööw et al. 2019).

2.3.11 Discussion

China is a leading country in the global mining sector for their underground coal mining activities. It has also tremendously published articles related to coal mine accidents (Chen et al., 2019; Nie et al. 2019; Gui et al., 2019; Qin et al., 2019; Xiao et al., 2019; Lin, Wei , and Junjie, 2019; Lyra, 2019; Cordeiro et al., 2019). Other countries also reported on mining accidents, such as Brazil (Lyra, 2019; Cordeiro et al., 2019), United States of America (Düzgün & Leveson, 2018), India (Prasad et al. 2015; Aliabadi et al. 2018; Aliabadi et al. 2019), and Spain (Gil-jiménez et al. 2017; Sanmiquel-pera & Bascompta, 2019). Despite an abundance of research on mining accidents, efforts to review the recent influencing factors on safety culture in the mining industry using Systematic Literature Review (SLR) in year 2016 until 2020 are not available. Therefore, this SLR study is to fill a gap by connecting the similarities or differences of influencing factors in safety culture studies from various mining industries worldwide. Based on the PRISMA approach, three main themes and seventeen sub-themes from 33 articles were successfully developed using thematic analysis after identification, screening, and eligibility processes on 4000 articles related to safety culture in the mining industry. The findings in Figure 2.12 are in line with the Reciprocal Safety Culture Model (Cooper, 2000) which focused on three dimensions of safety culture; psychological, situational, and behavioural.

This Systematic Literature Review (SLR) collected, analysed, and summarised the existing peer-reviewed published literature on safety culture in the mining industry by applying the PRISMA approach. This systematic review was guided by the study of Parris and Peachey (2013) and followed the clear steps provided by Khan, Kunz, Kleijnen, and Antes (2003) to guarantee a scientific and non-biased procedure in selecting and analysing articles. The results from this review provide sufficient reasons for researchers and practitioners to understand safety culture as a complex, relevant, and subset of organisational construct which is important for objective 1 to investigate the influencing factors of safety culture for psychology, situational and behavioural dimensions.

Furthermore, it is proven that poor safety culture is one of the main causes of mine accidents. A positive and healthy safety culture is a promising solution to preventing accidents in the mining industry. The influencing factors, such as psychological, situational, and behavioural dimensions are important to prevent mine accidents and give a good lesson to mine owners, miners, the government, regulators, and society on the importance of safety culture. A healthy safety culture in the mining industry seems difficult to achieve, but it is not impossible. Based on SLR findings, 47% of the factors influencing safety culture came from the behavioural dimension. Therefore, it is an early indicator for mine owners to tackle the behaviour issues among mine workers followed by psychological and situational dimensions, and the potential domain to be further investigated in this study, as shown in Table 2.13.

Table 2.13 Domains for psychological, situational, and behavioural dimensions

Psychological Dimension	Situational Dimension	Behavioural Dimension
SA= Safety Attitude PI= Peer Influence SK= Safety Knowledge PR = Perception of Risk	SR=Safety Rules AI = Accidents and Incidents RE=Reporting WE = Working Environment JS = Job Satisfaction	OC= Organisational Commitment SC= Safety Commitment OS = Ownership of Safety ST= Safety Training CO= Safety Communication RR= Reward and Recognition RA= Resource Allocation WC= Worker's Competencies

2.3.12 Limitations of SLR

While this SLR was conducted in a disciplined manner, some limitations may exist. First, the search process was limited to indexed journals that the researcher could access through a university library system and that were peer-reviewed in the English language. For that reason, this SLR cannot claim to cover non-indexed journals or dissertations since they were ineligible against the predefined inclusion criteria. With the broad interest in safety culture, there are possibly more empirical studies carried out in other languages that can confirm, clarify, or dispute the findings of the current SLR. Second, the methods and findings of the studies were supported by an assessment procedure to increase the accuracy level of the evaluation phase. Nevertheless, the attempt to aggregate the results of both qualitative and quantitative data analyses (featured in only two studies) may have limited the ability to adequately examine all methodological concerns when integrating the results. Finally, a meta-analytic study would be useful if sufficient data were available to assess the psychological, situational, and behavioural dimensions of the safety culture study in Malaysia.

2.3.13 Conclusion on SLR

The SLR results revealed the importance of the domain and dimension of safety culture especially for objective 1. Moreover, the SLR findings indicated that safety culture has not been researched in Malaysia for the past five years (2016-2020). Using this finding as guidance in a safety culture study, there may be a gap between SLR and findings from future works on the influencing factors of safety culture in the Malaysian context. The next chapter (Chapter 3) describes the methodology for the present research, including building the questionnaire, interview protocol, Delphi Techniques, and AHP approach in examining the psychological, situational, and behavioural dimensions that are important for the safety culture study to establish a safety culture framework for the mining industry in Malaysia.

2.4 Gap Analysis on Safety Culture Framework

2.4.1 Gap Analysis

The identification of research gaps can be obtained from (1) citation analysis, (2) content analysis, (3) systematic reviews, (4) meta-analysis, as well as (5) future research and limitations (Farooq, 2018). The researcher used a systematic review (systematic literature review, SLR) and meta-analysis (PRISMA) approach, as discussed in Section 2.3, to identify the research gap in the study. Systematic reviews (SLR) are the most widely used methods for identifying the research gap, whereby a researcher reviews and analyses the literature over a period of time. According to SLR on the influencing factor of safety culture in Section 2.3, the gap analysis can be illustrated as shown in Figure 2.15.

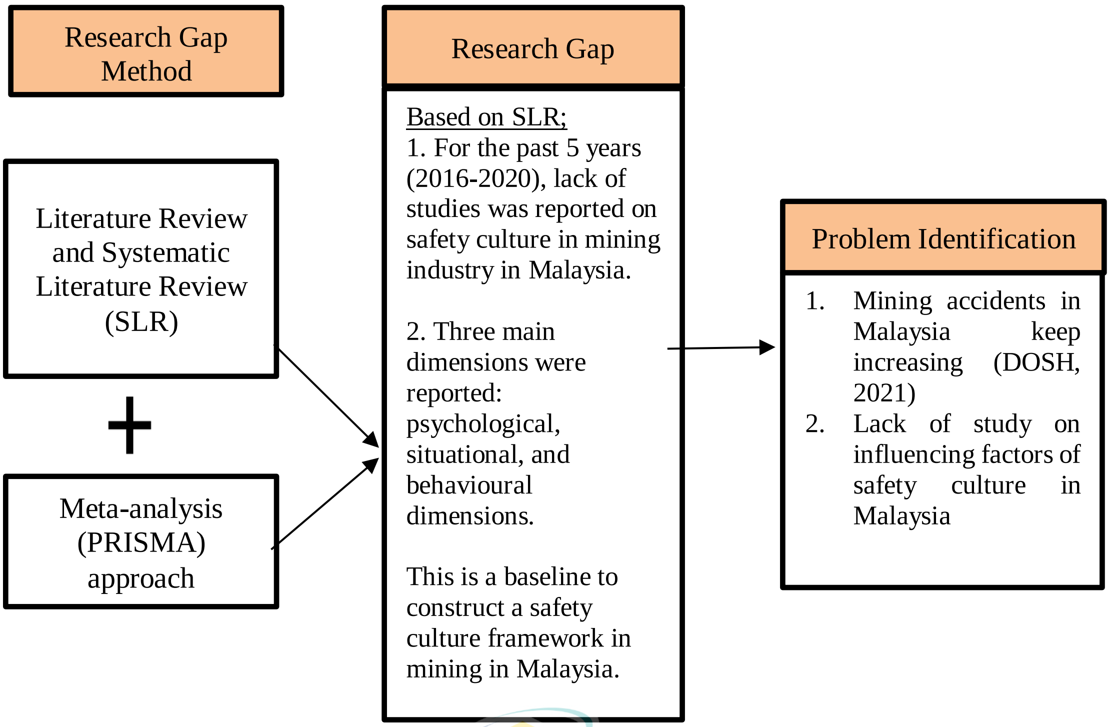


Figure 2.15 Gap analysis on safety culture research

2.4.2 Facilitators and barriers of safety culture implementation

In constructing a safety culture framework in the mining industry, there are many factors to consider, such as facilitators and barriers to safety culture. Facilitators include strong support and commitment by the Malaysian government to reduce industrial accidents, including in the mining sector. For example, Vision Zero is a strategic approach for preventing workplace accidents and promoting the health and wellbeing of employees (SOCSO Annual Report, 2019). Moreover, the Occupational Safety and Health Master Plan (OSHMP 2020) is introduced to inculcate a safe and healthy work culture for the well-being of workers, employers, and the country. In addition, mining experts with vast knowledge are also important in this research. Their input and views on the direction of the mining industry are really important to construct a framework for safety culture in Malaysia. The potential barriers that may hinder research in the mining industry based on previous scholars are (i) Lack of safety culture knowledge (Jiang et al., 2020), poor safety rules (Miao et al., 2020; Stemn et al., 2020), and poor communication channels (Jiang et al., 2020).

2.5 Concluding Remarks Chapter 2

This chapter touches on scenarios in the mining industry in Malaysia, various analysis on safety culture models. Cooper Safety Culture models was chosen in this study. SLR studies obtained the influencing factors for psychological, situational, and behavioural dimensions. The SLR results revealed the influencing factors three dimensions of safety culture which reflects to Objective 1 and Research Question 1.

CHAPTER 3

METHODOLOGY

This chapter highlights the research flow, justification for the selection of research methods, and detailed steps of the qualitative and quantitative methods to investigate the influencing factors of psychological, situational, and behavioural dimensions, as well as factors related to these dimensions in constructing a framework of safety culture in the Malaysian mining industry.

3.1 Basis for Safety Culture Research

The concept of Research Onion was developed by Saunders, Lewis, and Thornhill (2003) to describe the stages through which a researcher must pass when developing an effective methodology. The benefits of this concept are, thus, that it creates a series of stages under which the different methods of data collection can be understood and illustrates the steps by which a methodological study is conducted. The series of improvements on Research Onion was done by Saunders, Lewis, and Thornhill (2012), and the latest concept is by Saunders, Lewis, and Thornhill (2016), as shown in Figure 3.1. Based on the figure, the concept consists of five main stages or layers, as listed below:

i. Research philosophy - positivism, realism, interpretivism, and pragmatism
ii. Methodical choice - mono method quantitative, mono method qualitative, multimethod quantitative, multimethod qualitative, simple mixed method
iii. Strategies - experiment, survey, archival research, case study, ethnography, action research, grounded theory, narrative inquiry
iii. Time horizon: cross sectional, longitudinal
iv. Techniques and procedure: data collection and analysis

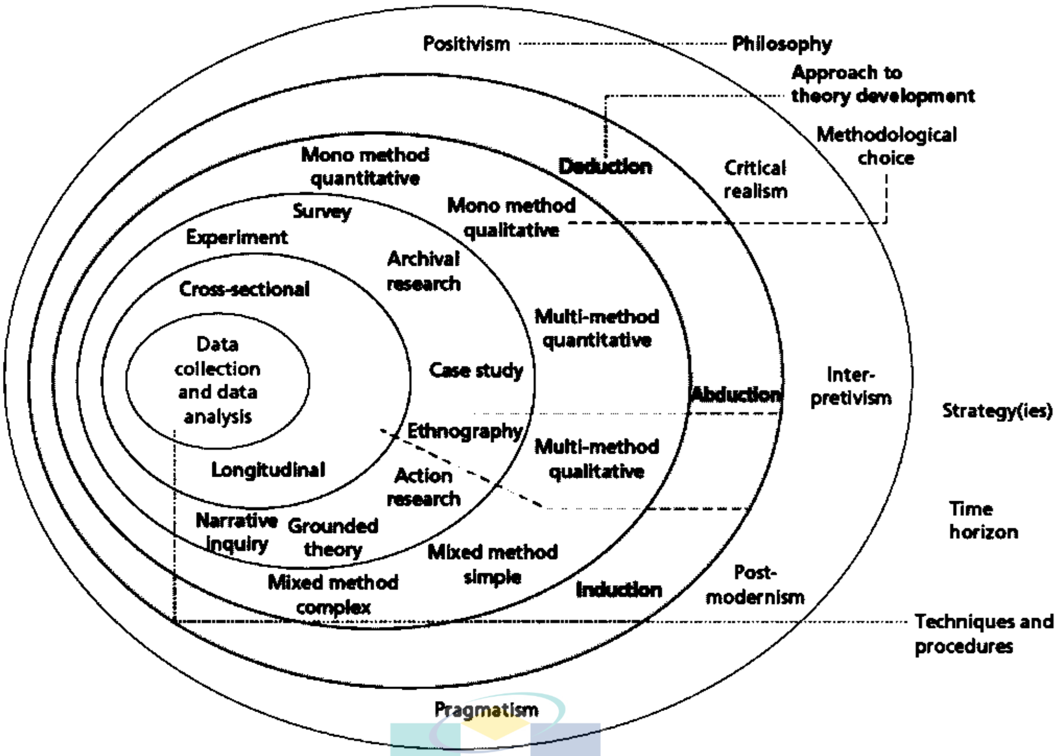


Figure 3.1 Research Onion

Source: Saunders et al. (2016)

The basis selection of safety culture study is guided by Saunders et al. (2016) as summarised in Table 3.1

Table 3.1 The selection of basis of study guided by Saunders et al. (2016)

Stages of Saunders Research Onion	**Criteria from Saunders Research Onion by Saunders et al. (2016)**	**Basis for safety culture studies in the mining industry in Malaysia**	**Section**
Research philosophy	i. positivism ii. realism iii. interpretivism iv. pragmatism	Pragmatism research philosophy	Section 3.1.1
Methodical choice (research method)	i. mono method quantitative, ii. mono method qualitative, iii. multimethod quantitative, iv. multimethod qualitative, v. simple mixed-method, vi. complex mixed- method	Mixed-method (sequential exploratory mixed-methods)	Section 3.1.4

Table 3.1 Continued

Stages of Saunders Research Onion	**Criteria from Saunders Research Onion by Saunders et al. (2016)**	**Basis for safety culture studies in the mining industry in Malaysia**	**Section**
Research strategies	i. experiment i. survey ii. archival research iii. case study iv. ethnography v. action research vi. grounded theory vii. narrative inquiry	Survey	Section 3.1.3
Techniques and procedures	Data collection and analysis	i. SLR ii. Preliminary iii. Delphi Technique iv. Analytical Hierarchy Process (AHP) v. Validation - Focus Group Discussion (FGD) and vi. Case study at volunteered mining company	Sections 3.3. to 3.7

Source: Saunders et al. (2016)

3.1.1 Justification on Pragmatic Paradigm

A research paradigm is defined as a "worldview with different philosophical assumptions associated with that point of view" (Tashakkori and Teddlie, 2010). However, a paradigm can also be *"a set of basic beliefs that deals with ultimates or first principles*" (Guba and Lincoln, 1994). A research paradigm allows researchers to recognise the philosophical assumptions and knowledge that guide their study and achieve their research aims (Creswell and Plano Clark, 2011).

The research philosophy or paradigm for this study was chosen based on the proposed research questions and aims. Considering the features of the four paradigms from Saunders et al. (2012), this study adopted the pragmatism paradigm and employed a mixed-method approach. The pragmatism paradigm is a suitable philosophical position for a mixed-method approach in which the researcher employs a combination of qualitative and quantitative methods to collect and analyse data in a single study (Creswell et al. 2011). The mixed-method approach is considered to provide a better understanding of the research problem (Creswell et al., 2011) and goes beyond a single approach (i.e., qualitative or quantitative) by utilising the advantages and limiting the disadvantages of each approach. In addition, the combination of both methods creates complementarity and enhances the effectiveness of the research model in answering the research questions (Johnson, Onwuegbuzie, and Turner, 2007).

The pragmatism paradigm leads researchers to use mixed-method approaches to unpack research problems that cannot be addressed by a single approach (Doyle, Brady, and Byrne, 2009). In this study, the pragmatism paradigm guided the qualitative method in collecting, analysing, and interpreting data to generate a better understanding of safety culture in the mining industry in Malaysia. Semi-structured and in-depth interviews were employed to collect qualitative data, and thematic data analysis was used to analyse the emergent narratives. The qualitative method was conducted first as an exploratory study to identify the safety culture in the mining industry from mine owners or senior managers and to understand how their exited safety culture shaped organisational climate. As the SLR identified, there is a lack of qualitative studies exploring safety culture, and none have been conducted in the context of the mining industry in Malaysia. Therefore, the qualitative study is vital in exploring safety culture and examining the perceptions of top mining leaders with respect to safety culture. The qualitative study was expected to contribute to the framework of safety culture by evaluating three main dimensions (psychological, situational, and behavioural) from the perspectives of mine owners, mine workers, and legislators in the mining industry in Malaysia.

3.1.2 Justification on Deductive Approach

The deductive research approach for this study was chosen based on the research questions and aims. The deductive approach is suitable because it portrays the general research problem to the specific research problem (Creswell, 2012). In this study, the safety culture issues are well-known in various industries, such as the mining industry. To be more specific, the safety culture study in mining in Malaysia less explored. The flow of deductive research is also suitable within a safety culture. It starts with (i) theory and hypothesis, (ii) observation and test, (iii) confirmation or rejection of theory and hypothesis, and (iv) data collection that is used to evaluate propositions or hypotheses related to an existing theory.

3.1.3 Justification on Survey Research Strategy

Saunders et al. (2012) stated eight types of strategies for conducting research in their Research Onion Philosophy. The strategies are experiment, survey, archival research, case study, ethnography, action research, grounded theory, and narrative inquiry. A research strategy refers to how to approach the research, from the topic to the processes, as designed by the researcher to avoid ambiguity and false leads (Gill, Johnson, and Clark, 2010). In this study, a survey was chosen as the main research strategy. Many studies have been conducted on safety culture in the mining industry, such as those by Ajith and Ghosh (2019), who used a survey method (questionnaire) in gold mining in Kenya and China (Arntz, 2016). A questionnaire is the simplest and most often used method for primary data collection. It is also inexpensive, practical, and obtains fast results from the respondents within the given timeframe. In addition, this study also conducted interviews with the Expert Panel in the mining industry in Malaysia. The appointments were scheduled based on their availability and conducted using the Google Meet platform.

3.1.4 Justification on Mixed-Method Research Design

A mixed-method design was chosen for the safety culture study for several reasons in line with Stentz, Plano Clark, and Matkin (2012). Mixed-method research is defined as *"an approach to inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks"* (Creswell, 2014). Creswell (2014) emphasised the benefits of integrating quantitative and qualitative approaches in mixed-method designs; therefore, this study took full advantage of and minimised the limitations of each approach. The purpose of the study design is to develop more comprehensive and reliable understandings, enhance result validity, and investigate contextualised understandings from an Expert Panel in the mining industry using an open interview, questionnaire survey, and the data were analysed using qualitative and quantitative methods. The validation of the framework was validated by Focus Group Discussion (FGD) and a case study at a volunteer mining company.

In safety culture studies, qualitative and quantitative approaches provide a good platform to analyse safety culture in the mining industry in Malaysia and come out with a new discovery in the area of existing safety culture models or theories (Saunders et al. 2012). Furthermore, the choice of mixed methods has the potential to uncover new interpretations about interactions and influencing factors on safety culture. Important elements of the safety culture factors on the psychological, situational, and behavioural dimensions have been investigated. Scholars have raised an important issue in employing mixed methods with respect to the ordering of qualitative and quantitative studies and which approach answers which research question (Bryman, 2006; Franco and Matos, 2015; Stentz et al., 2012).

Four criteria are used to classify mixed-methods designs: implementation, priority, stage of integration, and theoretical perspective (Creswell, 2003). Based on these criteria, mixed-method designs can be categorised as sequential or concurrent research. Concurrent designs are conducted based on parallel data collection and analysis of both qualitative and quantitative phases and are categorised in three forms: triangulation, nested, and transformative designs. The findings of both qualitative and quantitative studies in a concurrent design are compared at the end of the research. In a sequential design, researchers collect either qualitative or quantitative data first, followed by the other method in the second phase. There are three types of sequential design: explanatory, exploratory, and transformative.

Taking on board the foregoing discussion, this study used exploratory sequential mixed methods (Creswell et al., 2011; Tashakkori and Teddlie, 2010) to answer the research questions. In this exploratory design, priority was given to the qualitative method, and the research results from the first phase were used to inform the subsequent quantitative study. The findings of the qualitative phase led to the final content (in addition to theory driven scales) of the questionnaire to best fit the sample and context.

The mixed-method examination in this research comprised in-depth interviews with mining industrial personnel such as Senior Mining Managers, Safety Managers, mine owners, or operators from Malaysian mining companies, designed to explore the leaders' views on the influencing factors of safety culture. The interviews drew out the interpretations and sense-making of the leaders (Weick 1993). This first phase aimed to gather information and explore the phenomenon of safety culture in the mining industry in Malaysia. Subsequently, questionnaires informed by the qualitative phase were used to collect data from mine experts working for Malaysian mining companies. Interviews with panel experts were also conducted and statistical analysis demonstrated the beneficial application of mixed-methods research as recommended by Venkatesh, Brown, and Bala (2013). Mixed methods were employed in this study because the phenomenon of safety culture has been researched mainly using quantitative methods, generalising from theory-based models of safety culture (Jiang et al., 2020). As discussed in the literature review and based on the findings of the SLR, this study used an exploratory approach to study the psychological, situational, and behavioural dimensions of safety culture in the Malaysian mining industry.

3.2 Research Methods: Mixed Methods

This study chose mixed methods, which are qualitative and quantitative approaches. In general, the main differences between qualitative and quantitative research methods are shown in Figure 3.2

Qualitative research methods	Quantitative research methods
• Expressed in motives and generalisations • Data in the forms of forms of words, images, transcripts, etc. • Each research is approached individually and individual measures are developed to interpret the primary data taking into account the unique characteristics of the research • Research findings usually presented in analysis by only using words.	• Expressed in the forms of variables • Data in the forms of numbers and specific measurements • Usually universal, like formulas for finding mean, median, and mode for a set of data • Research findings can be illustrated in the forms of tables, graphs, and pie-charts,

Figure 3.2 Differences between qualitative and quantitative

Source: Amaratunga et al. (2002), Jebb (2015)

Moreover, there are two types of data; primary and secondary. Primary data is a type of data that has never existed before; hence, it was not previously published. Primary data is collected for a specific purpose, i.e., it is critically analysed to find answers to research question(s). Secondary data, on the other hand, refers to a type of data that has been previously published in journals, newspapers, magazines, books, online portals, and other sources.

To summarise, Table 3.2 shows the research strategy, techniques, and type of data for the safety culture study, and Figure 3.4 shows the flow of the research design

Table 3.2 Research strategy, techniques, and types of data for the safety culture study

Objective	**Strategy**	**Techniques**	**Type of Data**
1. To investigate the influencing factors for psychological, situational and behavioral dimensions on safety culture prevailing in the mining industry in Malaysia.	• Secondary data (Systematic Literature Review, SLR) • Primary data	• Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) • Preliminary Study-Interviews with Expert Panel • Delphi I and Delphi II (interview and questionnaire) • The questionnaire was validated first	Qualitative Qualitative and Quantitative
2. To develop a framework on safety culture in the mining industry in Malaysia	• Primary data	• Analytical Hierarchy Process (AHP). • Questionnaire was validated first	Quantitative
3. To validate the proposed framework of safety culture in the mining industry in Malaysia	• Primary data	• Validate by Expert (Focus Group Discussion) • Case study/Pilot test at a volunteered mining company	Qualitative Quantitative and Qualitative

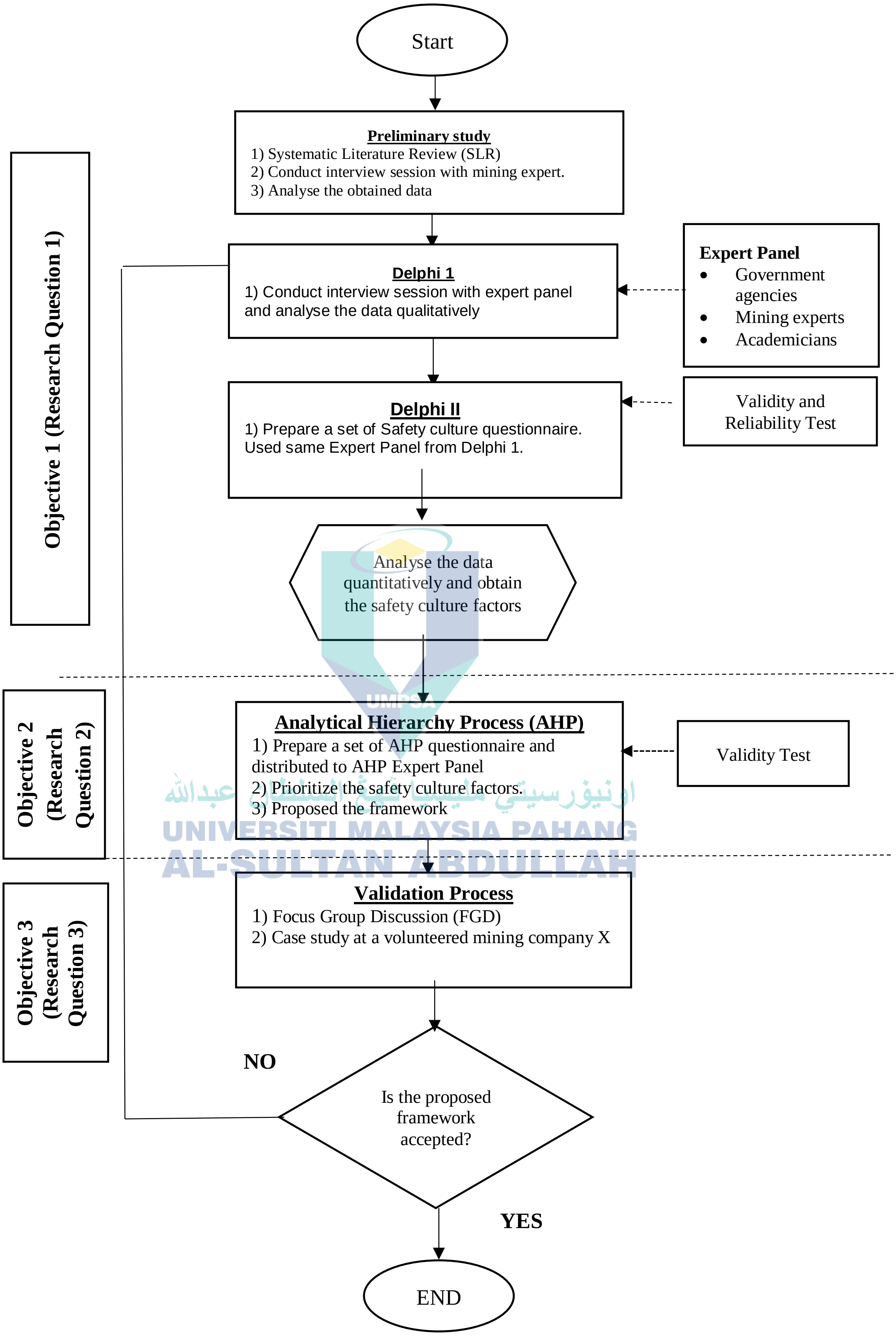


Figure 3.3 Research Design of the Safety Culture Study

3.2.1 Qualitative research methods

A qualitative method was applied to examine the influencing factors of psychological, situational, and behavioural dimensions in the mining industry in Malaysia.

3.2.1.1 Design

In-depth interviews were conducted as the tool of inquiry as they enable a *"more accurate and clearer*" picture of the respondents' position or behaviour'' (Ghauri and Gronhaug, 2002). They also enable participants to clarify and elaborate on their answers. The interviews were conducted by using Malay and English. All the correspondence, consent forms, and information sheets were attached to the original English documents. Table 3.3 shows the involvement of mining experts and validators, and the type of study design for each research method.

3.2.1.2 Participants

There is no sampling population since the Delphi Technique has been used and the control measure was the years of working experience of the mining experts in mining industry as mentioned in Section 3.4.3 and Table 3.8. The overall participants involved in this study were grouped into mining experts and validators, as shown in Table 3.3.

Table 3.3 Involvement of Mining Experts and Validators and Type of Study Design for Each Research Method

Stage	Main Research Method	Number of Mining Expert Involved	Number of Validators Involved	Type of Study Design	
				Qualitative	Quantitative
1	Preliminary Study on Safety Culture	6	-	✓	
2	Delphi 1: Open-ended Interview session	21	-	✓	
	Delphi II: Questionnaire	18	3		✓
3	Analytical Hierarchy Process (AHP)	5	1		✓
4	Focus Group Discussion (FGD)	-	5	✓	

Table 3.3 Continued

Stage	Main Research Method	Number of Mining Expert Involved	Number of Validators Involved	Type of Study Design	
				Qualitative	Quantitative
5	Case study at a volunteer mining company	-	3	✓	✓

3.2.1.3 Dimension and domain for qualitative study

At the preliminary stage, the open-ended interview session was guided by the following dimensions and domains obtained from the SLR study, as shown in Table 3.4. However, these domains were changed once the first-hand data input was obtained from the mining experts in Delphi I and Delphi II.

Table 3.4 Dimensions and domains for qualitative study

Dimension	Factors	Symbol
Psychological	1. Management concern on workers	MC
	2. Safety attitude	SA
	3. Job satisfaction	JS
	4. Health of worker	HW
	5. Peer influence	PI
Situational	1. Safety policy	PO
	2. Safety audit	AU
	3. Safety rules	SR
	4. Competent SHO	SO
	5. Safety education	SE
	6. Safety programme	PR
	7. Safety planning	PL
	8. Medical surveillance	MS
	9. Safety competency	CO
	10. Safety signage	SS
Behavioural	1. Management action and responsibility	MA
	2. Safety communication	SC
	3. Leadership	LE
	4. Safety training	TR
	5. Safety awareness	AW
	6. Safety reporting	RE
	7. Safety promotion	SP
	8. Enforcement on safety rules	EN
	9. Reward and punishment	RP

3.2.1.4 Interview Protocol

The interview protocol was involved at the preliminary stage and Delphi I (open -ended interview session). A semi-structured interview was used to investigate the participants' points of view on the current safety culture awareness, practices, or implementation in the Malaysian mining industry.

3.2.1.5 Qualitative Measures

The qualitative parts involved in this study were the interview session for the preliminary study and Delphi I. All responses from different experts were analysed using thematic analysis (Nowell, Norris, White, and Moules, 2017), as shown in Figure 3.4. Table 3.3 shows the involvement of mining experts and validators and the type of study design for each research method.

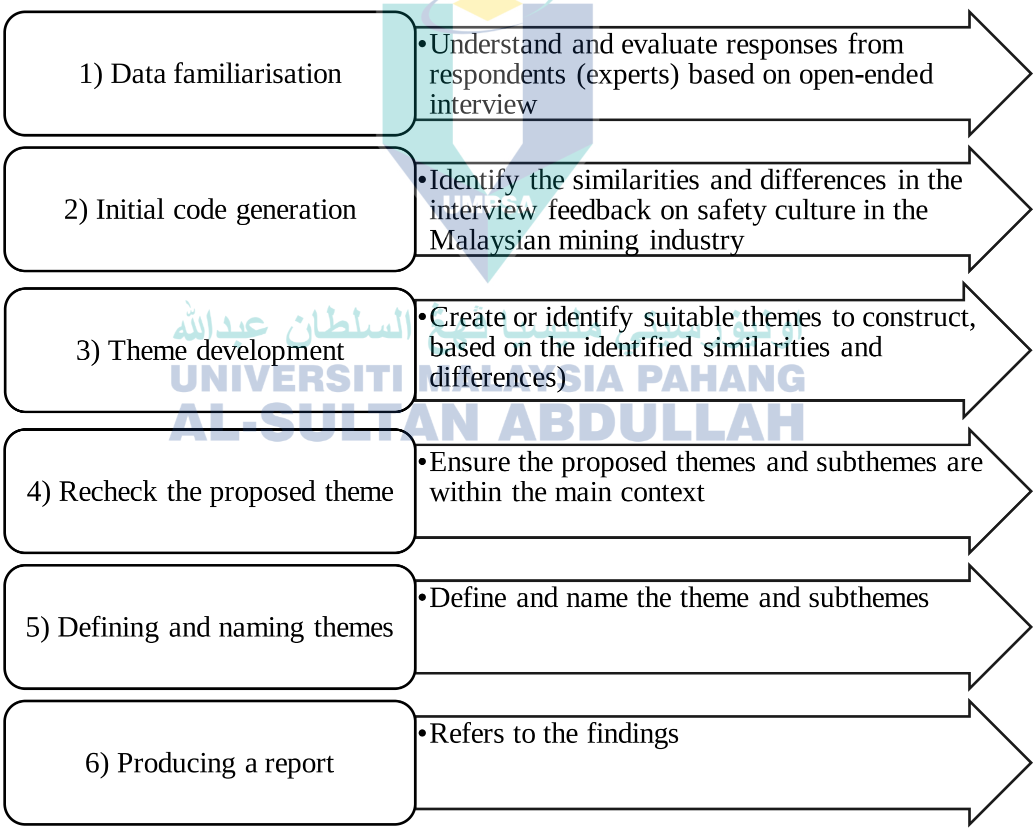


Figure 3.4 Steps for Thematic Analysis

Source: Nowell et al. (2017)

3.2.2 Quantitative research methods

Zohar (1980) is one of the pioneers in developing safety climate/culture questionnaires. It consists of a series of questions that measure employees' beliefs, attitudes, values, and perceptions, as well as important input to the development of a safety culture (e.g., management commitment). (Guldenmund, 2000; Gadd and Collins, 2002). Furthermore, as in this study, it is interesting to use safety climate questionnaires because there is a correlation between one or more scales and some criterion outcome variables, such as accidents, near misses, or safety-related behaviour, possibly with reference to different subgroups (Guldenmund, 2007).

Safety culture questionnaires are also very useful for measuring changes pre- and post-interventions and generating a broad picture of an organisation's safety issues. However, the drawbacks of this method include low response rates due to misinterpretation of the objectives of the questionnaire or understanding of the questions, poor understanding or explanation of results, low levels of employee literacy, and fear of reprisals or blame (Guldenmund, 2007).

In this study, the quantitative approach of sending the questionnaires on safety culture to the mining experts for Delphi II and the Analytical Hierarchy Process (AHP) study touched on the three main dimensions of safety culture (psychological, behavioural, and situational). The mining experts, such as the mine owners, mining consultants, and safety managers, agreed to voluntarily participate in this study, with high response rates for Delphi II (85.7%) and the AHP study (100%).

3.2.2.1 Sample and procedures

The data for this Delphi study were collected from the respondents, known as Delphi experts, who have vast experience in mining operations and activities, as shown in Table 3.8. All of them were contacted via email and volunteered to participate in this study. The official letters were sent to them for their self-record. All the experts who submitted their consent forms indicated their agreement to be involved in this research. The procedures for each research method were discussed in detail in Sections 3.3 to 3.7.

3.2.2.2 Quantitative Measures

For quantitative measures, there were two main parts to this study. The first part was Delphi II, which involved questionnaire survey. All items were measured on a five-point Likert response scale, ranging from “1 = strongly disagree” to “5 = strongly agree” (Robinson, 2014), where a higher value on the scale indicates a good practice in safety culture. The online questionnaire survey using Jotform was distributed directly to the Delphi experts with their permission first. The completed questionnaires were returned directly to the researcher. After three weeks, questionnaires were returned, giving a response rate in percentage. Incomplete or disengaged responses to questionnaires were discarded due to incompleteness. Disengaged responses could be recognised when participants selected only one answer throughout the questionnaire.

The second part was the Analytical Hierarchy Process (AHP) Questionnaire Survey. It was conducted once the responses from Delphi II were analysed. The AHP survey was used to prioritise the influencing factors of safety culture based on the feedback of experts. The online questionnaire survey was emailed to another expert to answer within three weeks. The scale used for AHP is the Saaty Scale (1-9) as proposed by Saaty (1977), as shown in Table 3.5, and Table 3.6 shows the category of questions and the elements that were asked in the questionnaire survey.

Table 3.5 Saaty Scale for AHP

Scale (1~9)	Definition
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very strong to extreme importance
9	Extreme importance

Source: Saaty (1977)

Table 3.6 Domains used for questionnaire survey and elements in AHP

Psychological Dimension	Situational Dimension	Behavioural Dimension
Matrix 5x5	Matrix: 10X10	Matrix 9x9
10 questions consist of element of;	44 questions consist of elements of;	36 questions consist of elements of;
1. Management concern on workers = MC	1. Safety policy = PO	1. Management action and responsibility = MA
2. Safety attitude = SA	2. Safety audit = AU	2. Safety communication = SC
3. Job satisfaction = JS	3. Safety rules = SR	3. Leadership = LE
4. Health of worker = HW	4. Competent SHO = SO	4. Safety training = TR
5. Peer influence = PI	5. Safety training = ST	5. Safety awareness = AW
	6.Safety programme = PR	6. Safety reporting = RE
	7. Safety planning = PL	7. Safety promotion = SP
	8. Medical surveillance = MS	8. Enforcement= EN
	9. Safety competency = CO	9. Reward and punishment = RP
	10. Safety signage = SS	

3.2.2.3 Control variables

The years and working experience are control variables in the study (Chang, Bai, and Li, 2015; Gyu Park, Sik Kim, Yoon, and Joo, 2017). It means the experts must understand the nature of mining operations, be currently involved in or work in the Malaysian mining industry, or be experts about safety culture.

3.3 Stage 1: Preliminary Study on Safety Culture

3.3.1 Justification on Preliminary Study

The aim of the preliminary study was to investigate the current status of safety culture awareness and practises in the Malaysian mining industry by interviewing mining experts in Malaysia. The findings proved the feasibility of carrying out the study by obtaining first-hand data from mining experts and provided a platform to further investigate what the influencing factors of safety culture are in the context of the Malaysian mining industry. This work involved an open-ended qualitative interview session, which was performed via the Google Meet platform in March 2021. Open-ended questions employed in the study aimed to obtain respondents' thoughts, perceptions, and experiences on the safety culture in the mining industry in Malaysia. The duration of the individual interviews was between 30 and 45 minutes. Six mining experts agreed and volunteered as respondents in this study. They were also willing to share their vast experience in the mining industry.

3.3.2 Participants of the Preliminary Study

According to David (2019), when using qualitative research techniques like interviews, it is frequently a good idea to start with 5 participants and then increase that number by 5, depending on how complex the subject matter is. Therefore, at the preliminary study stage, ten invitation letters for participation in this study were sent via email to mining experts. However, only six of them agreed to share their experience on safety culture in the mining industry which is consider enough for preliminary study as suggested by David (2019). The selection and criteria for the participation were based on their extensive experience in mining, with a minimum of 10 years in the mining industry in Malaysia. This is important to understand the significance of research on safety culture in the mining industry and also understand the awareness level of safety culture among mine operators and miners in Malaysia. The background of the respondents involved in the preliminary study was available in supporting documents upon request. Each interview session was first approved by the respondents. Interviews were recorded, transcribed, and analysed. The curriculum vitae of the participants were appended as a supporting document upon request. Appendix A to D showed the documents related to Preliminary study.

3.3.3 Open Ended Question

The interview protocol involved at the preliminary stage was used to investigate participants' perceptions of safety culture in the mining industry. It was conducted in March 2021. The interview protocol consists of ten open-ended questions that were used as guidance during the interview session. A semi-structured interview was used to investigate on the participants' points of view on current safety culture awareness, practices, or implementation in the Malaysian mining industry. For the preliminary stage, the interviews were guided by a set of interview protocols that included open-ended questions such as:

1) *How can the safety culture be defined in general?*
2) *How would you define the safety culture awareness in mining organisation?*
3) *What are the benefits of safety culture practises in the mining industry?*

4) *In your opinion, what are the challenges to promote safety culture practises in the mining industry in Malaysia?*

The interviews were conducted using the Google Meet platform at a time convenient to them, and lasted on average between 45 and 60 minutes. All interviews were audio-recorded with participant consent. The examples of participant consent form, email invitation, appointment letters and complete questions were appended in Appendix A, Appendix B, Appendix C and Appendix D, respectively. The data collection and data analysis of the preliminary study were further discussed in Chapter 4.

3.4 Stage 2: Delphi I and Delphi II

The Delphi method is a structured communication technique, originally developed as an interactive forecasting method that relies on a panel of experts. This method is highly used in Collective Intelligence (Dalkey, Norman, Helmer, and Olaf, 1963). It refers to shared or group intelligence that emerges from the collaboration, collective efforts, and competition of many individuals and appears in consensus decision-making (Dalkey et al., 1963). The Delphi I, which involved the interview sessions with mining experts, was conducted in April 2021 to May 2021, while the Delphi II: Online Safety Culture Questionnaire was started in June 2021 to July 2021. An example of a consent form for Delphi I Experts involved in Delphi I and Delphi II were appended in Appendix E. The data collection and data analysis for the Delphi study are further discussed in Chapter 4.

3.4.1 Justification on the selection of Delphi Techniques

The Delphi technique begins with the initial development of a questionnaire focusing on the identified problem by the initiator. Next, an appropriate respondent group was selected, and the earlier prepared questionnaire was mailed to each of them. The respondents answered the questionnaire independently, and they returned it to the researcher. The feedback from the questionnaire was summarised and used to develop a feedback summary and a second questionnaire for the same respondent group (Dalkey et al., 1963). After reviewing the feedback summary, the respondents continued to rate priority ideas included in the second questionnaire, then mailed back their responses. The process was repeated until investigators reached an agreement on the topic being discussed. A final summary report was issued to the respondent group. The main features of the technique are anonymity, numeric response, and feedback (Dalkey et al., 1963).

Moreover, in the Delphi technique, anonymity is guaranteed since the process is coordinated by a research team using, in most cases, an online platform or e-mail, thus avoiding any interaction between participants. After the first round, the research team analyses and summarises the responses of the panel of experts in order to provide feedback to participants for the following round. Whereas anonymity reduces the effect of dominant individuals on participants' responses, the use of controlled feedback encourages experts to reassess their initial judgements based on the information provided by the research team in each round. Feedback thus allows each participant to generate additional insights about the specific questions or items and, consequently, change his or her responses during the group's opinion. This means that the responses given to each item can vary across rounds, thereby favouring the convergence of opinions (Linstone and Turoff, 1975). In this respect, the Delphi method is well suited as a consensus-building technique (Juana, 2021). The determination of consensus among participants is important for the Delphi method. McKenna (1994), drawing on Loughlin and Moore's work (1979), suggests that consensus should be equated with 51% agreement amongst respondents, Crisp (1997) recommends 70%, while Green, Jones, Hughes, and Willimas (1999) opt for an 80%. Alternatively, Crisp (1997) questions the value of using percentage measures, suggesting that the stability of the responses through a series of rounds is a more reliable indicator of consensus. In contrast, this technique also has disadvantages. The judgement may be from a selected of people and may not be representative of the other people. It is also more time-consuming than the focus group discussion and requires skill in written communication (Dalkey et al., 1963). The summary of comparison on the selection of Delphi technique was summarized in Table 3.7. While these methods differ in their feedback systems, iterative nature, and interaction style, they are comparable to the Delphi method in that they make use of expert opinions or structured processes. While other methods may entail direct interaction, single sessions, or less structured approaches, Delphi stands out for its iterative, anonymous, and structured feedback process. Therefore, Delphi was selected for this study.

Table 3.7 Comparison of various methods with Delphi in terms of process, interaction, iteration and feedback

No	Method	Purpose	Comparison of various methods with Delphi in terms of				Ref
			Process	**Interaction**	**Iteration**	**Feedback**	
1.	Nominal Group Technique (NGT)	To generate, evaluate, and prioritize ideas or solutions from a group of participants.	• Participants individually generate ideas. • Ideas are shared one at a time in a round-robin manner. • Ideas are discussed for clarification. • Each participant ranks or votes on the ideas. • Results are summarized and reviewed.	• **Interaction**: NGT involves face-to-face interaction, while Delphi typically involves anonymous input.	• **Iterations**: NGT usually involves a single session with structured discussion, whereas Delphi involves multiple iterative rounds.	• **Feedback**: NGT provides immediate feedback through discussion and voting, while Delphi uses anonymous feedback to reduce bias.	Graefe and Armstrong (2011)
2.	Round-Robin Brainstorming	To generate a diverse range of ideas from group participants.	• Participants take turns sharing ideas in a structured round-robin manner. • Ideas are recorded and discussed. • The group may rank or evaluate ideas based on predefined criteria.	• Round-robin brainstorming is conducted in a group setting with real-time interaction, whereas Delphi is typically anonymous.	• Round-robin brainstorming is usually a single session, while Delphi involves multiple rounds with iterative feedback.	• Delphi uses iterative rounds of feedback to refine opinions, whereas round-robin brainstorming provides immediate feedback.	Anand, Pujar and Rao (2021)

Table 3.7 Continued

No	Method	Purpose	Comparison of various methods with Delphi in terms of				Ref
			Process	Interaction	Iteration	Feedback	
3.	Consensus Building	To achieve agreement among stakeholders on a specific issue or decision.	• Facilitated discussions or negotiations among participants. • Structured dialogue to resolve disagreements and build consensus. • Techniques such as mediation are used to facilitate agreement.	• Consensus building involves direct dialogue and negotiation, while Delphi is typically anonymous and iterative.	• Consensus building may involve multiple discussions, but not necessarily structured iterative rounds like Delphi.	• Delphi provides iterative feedback to refine opinions, whereas consensus building uses discussion and negotiation to achieve agreement.	Tajima, Yamaguchi, and Shiroyama (2024)
4.	**Expert Judgment**	To leverage the knowledge and insights of subject matter experts for decision-making	• Experts provide their judgments or forecasts on a specific issue. • Their input is collected, analyzed, and used to inform decisions	• Expert judgment may involve individual consultations or group settings, while Delphi is typically structured with anonymous feedback.	• Expert judgment may not involve iterative rounds, whereas Delphi involves multiple rounds to refine opinions	• Delphi uses iterative feedback to achieve consensus, whereas expert judgment may not have a structured feedback mechanism.	Katzav, Thompson, Risbey, Stainforth, Bradley and Frisch (2021)

Source: Graefe and Armstrong (2011), Anand et al. (2021), Tajima et al. (2024), Katzav et al. (2021)

3.4.2 Flow of Delphi Technique

The Delphi technique is defined as "a group procedure involving interaction between the researcher and a group of identified experts on a certain issue, usually through a series of questionnaires" (Skutsch and Hall, 1973). The panel of professional principles' knowledge and experiences served as the foundation for reaching a group consensus. The number of rounds employed in a Delphi study varies depending on the research's goal.

According to Bammer, Donald, and Deane (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. 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 here. 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 consensus.

Furthermore, the number of rounds of questionnaires is determined by the consistency or convergence of results, not by consensus (Linstone and Turoff, 2011; Lear, 2020; Lemmen, Woopen, and Stock, 2021). *"The importance of the Delphi is not in producing high reliability consensus data, but rather in alerting the participants to the complexity of situations by compelling, cajoling, persuading, and seducing them to think, by having them challenge their assumptions"*. This differs from a more traditional panel or forum, where unanimity is desired and often imposed, resulting in research data errors (Linstone & Turoff, 2011).

This research applied a two-round Delphi (known as Delphi I and Delphi II) iterative consultation procedure with panel experts. This method is commonly used in research (Peeraer and Van Petegem, 2015; Yeh and Cheng, 2015), and its validity for questionnaire construction has been established (Blasco, López, and Mengual, 2010). The Delphi techniques used covered the following aspects;

a) Selection of Delphi Experts: Experts who participated in the Delphi method consist of;

i. Mining consultant that has vast experience related to mining operation
ii. A well experienced safety officer from a mining company
iii. CEO of a mining company
iv. Government agency/authority that is involved with mining policy, regulations, and legislation related to the mining industry in Malaysia
v. Experts/Educators or professors who conduct an extensive research on safety culture.

Appendix F and G showed the example of invitation letter and official appointment letters for Delphi I Panel Experts.

b) Delphi I: Open ended interview session.

i. This session was conducted using the Google Meet Online platform based on the availability of all Delphi experts. The findings of Delphi I were analysed using thematic analysis according to Nowell et al. (2017) and provided as a basis for the construction of questionnaire in Delphi II. Open ended question was appended in Appendix I.

c) Questionnaire design for Delphi II: The questionnaire focused primarily on the following aspects;

i. Clarity and comprehension of safety culture key concepts: psychological, situational, and behavioural dimensions.

d) Delphi applications:

i. Once the questionnaire was ready, the whole process described above was implemented (questionnaire sending, reception, feedback, etc.). As soon as the consensus was reached, the process was completed. Appendix M and Appendix N showed the validators and validation form related to safety culture questionnaire.

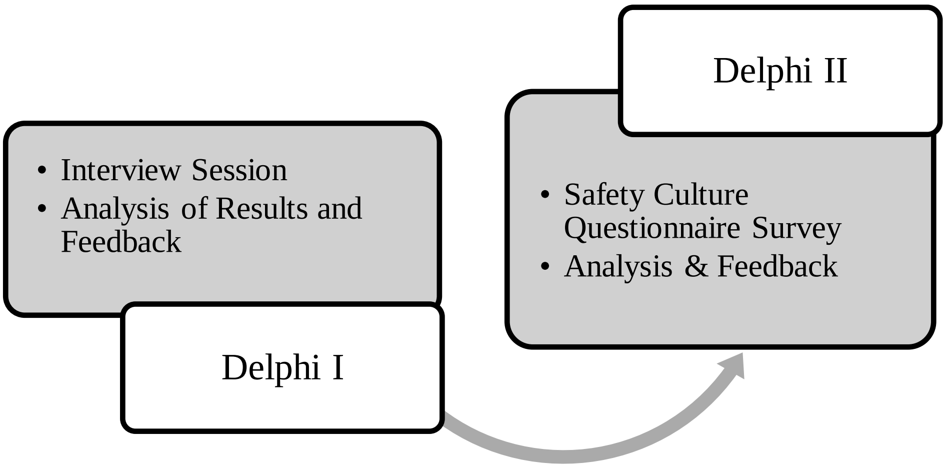


Figure 3.5 Delphi Method (2^{nd} round)

Source: Peeraer and Van Petegem (2015)

Delphi I: The Delphi procedure usually starts with an open-ended survey or questionnaire in the first round. This is used to get particular information from the Delphi panel about a certain topic (Custer et al. 1999). After the panellists have responded, the researchers compile their findings into a well-organised document. In Round One of the Delphi method, it is appropriate and typical to utilise a structured document as the questionnaire that is based on the literature or what is previously known about the issue (Brady, 2015).

Delphi II: Each panel member will receive a questionnaire in the second round and assess the items generated by the researcher from the information received in the first round. Members of the panel may be asked to rate or "rank-order" items in order to determine preliminary priorities. Areas of dispute and agreement are found as a result of “round two" (Ludwig, 1997). During this round, the panellists' responses begin to build consensus, and the ranking order may be established (Ab Latif, Dahlan, Ab Mulud, and Mat Nor, 2017). The questionnaires were sent out by Jotform online and also through email in order to increase the probability of quick responses. For the return of questionnaires, the researcher applied a two-week deadline. In the event that the experts did not meet the proposed deadline, follow-up contacts were made. The statistical data (rankings) were analysed in Delphi II to determine the mean ranks and sample standard deviation.

3.4.3 Delphi Experts

3.4.3.1 Selection and Criteria of Delphi I Experts

The most crucial phase in the entire process of conducting a Delphi survey is selecting relevant subjects for the expert panel because it directly reflects the quality of the results (Taylor & Judd, 1989). The Delphi method is intended to elicit expert viewpoints in a short amount of time. This necessitates that the Delphi subjects be knowledgeable in the areas of competence required by the issue. Professional group memberships, word-of-mouth recommendations from professional peers, and other sources that promote or determine the participation of people who are most qualified and have a good knowledge base of the topics at hand are examples of ways to identify expert panel members. Diverse backgrounds of panel members can often be beneficial since it adds to a larger and deeper understanding of the subject by allowing for diverse and unique opinions on the same issue (Nworie, 2011).

Experts on the Delphi panel should be knowledgeable about the target issue and display knowledge that members of the general public and recognised professions would consider to be of expert quality (Hallowell and Gambatese, 2010). The response rate in each subsequent round can be used to determine each panel member's commitment to participate in a multi-round Delphi (Keil, Tiwana, and Bush, 2002). True experts in a subject often have a depth of information, but they are usually quite busy and may not be able to fully participate. Questions that are relevant, concise, and well-written can occasionally increase participation. According to Adler and Ziglio (1996), to be designated an "expert," Delphi participants must meet four criteria:

i. knowledge and expertise with the issues under examination
ii. capacity and willingness to engage
iii. enough time to participate in the Delphi
iv. effective communication abilities

Additionally, according to Hallowell and Gambatese (2010), the criteria for determining whether or not a person qualifies as an expert might be vague. The use of an unbiased sample is one of the most important considerations in any study. This also implies that the procedure for panel selection is unbiased. Expert panellists, according to

Hallowell and Gambatese (2009), must meet certain criteria or standards. One of these may be a "demonstration of knowledge that members of recognised professions and the general public deem to be of expert quality" (Hallowell and Gambatese, 2010). For instance, a certification criterion could be at least 10 years of professional experience in the mining industry or in the Occupational Safety and Health field. Another criterion would be that the person works as a senior lecturer or a professor at an accredited university. Therefore, in this Delphi method, the criteria of experts are shown in Table 3.8.

Table 3.8 Criteria for selection of Delphi Experts

Criteria	**Background of Experts**			
	Mining industry	**University**	**Government agencies**	**OSH field**
Working experience	At least 10 years and above for each respective sector			
Area of expertise	Mining operation or Mineral development or Mine Safety or Mining policy or Mineral R&D	Mining operation or Mineral development or Mine Safety or Mineral R&D	Mining operation or Mineral development or Mining policy	OSH, especially safety culture practices and implementation Organisational behaviour
Example of Position	Mine owner, Mine perator, Top Management (CEO/President/Vice President) Mining consultant Mining Manager SHE Mine Manager Mining Safety Officer	Professor, Senior Lecturer, Researcher	Director of Mineral Development, Enforcer/Mine Inspector	SHE Manager, Safety Officer, Mine Safety Engineer

3.4.3.2 Size of Delphi I Experts

According to Rowe and Wright (1999), a Delphi panel can have as few as three members on the low end and as many as 80 on the high end. They discovered that the majority utilised a panel of between 8 and16 members, so they recommend a minimum of 8, although no direct link was identified between the number of panel members and their effectiveness. The researcher should think about how much time and money they have to complete the investigation. The expert panel's qualities, not its numbers, are used to determine quality representation. For the purpose of this study, the researcher contacted more than 30 potential experts in the mining industry and safety culture. However, 21 agreed to volunteer for this research, as shown in Table 3.9. This number is sufficient and within the Delphi’s size (3 to 80 panels), as mentioned by Rowe and Wright (1999). Appendix F and G showed the example of invitation letter and official appointment letters for Delphi I Panel Experts.

Table 3.9 List of Delphi Experts

Criteria	**Background of Experts**			
	Mining industry	**University**	**Government agencies**	**OSH field**
Working experience	At least 10 years and above for each respective sector			
Number (n) and Position	Mine owner/Operator (n=1) Senior Operating Mining Manager (n=1), Vice President Business Development (Mining) (n=1) Mining Consultant (n=3) Mining Manager (n=2) SHE Mine Manager (n=2) Mining Safety Officer (n=1)	Professors (n=1) Associate Prof (n=2) Senior Lecturer (n=2)	Director of Pahang Mineral Geoscience Department (n=1) Enforcer from DOSH (n=1)	EHS Superintendent (n=1), Safety Officer (n=2)

3.4.4 Instrumentation for Delphi Technique

The Delphi Technique, or method, applied two main survey instruments. The first instrument or known open-ended question for Delphi I aims to gather information on the influencing factors of safety culture in the Malaysian mining industry. Moreover, the experts were asked about the current awareness, practises, and implementation of safety culture in the mining industry, which was beneficial in designing the questionnaire in Delphi II.

The second survey or Delphi II consists of the development of a questionnaire based on the analysed input from Delphi I. The questionnaire was validated by a validator to ensure the quality and reliability of the questions. Moreover, the questionnaire was aimed at gathering experts' opinions on the influencing factors of safety culture. The adoption of a five-point scale, according to Allen and Seaman (2007), makes the scale more reliable. A "5" on the scale indicates that the topic is considered exceedingly essential, while a "1" indicates that the topic is considered entirely trivial.

3.4.5 Open Ended Question for Delphi I

The Delphi I applied interview session with open-ended questions for Delphi experts. Participant Information Sheet for Delphi I was emailed to all experts, as appended in Appendix I. The important part of the interview session was the questions related to the construction of safety culture in the Malaysian mining industry such as:

1. *Based on your experience, what are the individual/personal factors (how people feel) that contribute to a positive safety culture in mining industry?*
2. *How does the working environment (what the organisation has) contribute to a positive safety culture in mining industry?*
3. *What are the behavioural factors (what people do) that contribute to a positive safety culture in the mining industry?*
4. *What other factors contribute to creating a good safety culture in the mining industry?*
5. *What else could the mining company do to improve its safety culture?*

The interviews were conducted using the Google Meet platform at a time convenient to them and lasted on average between 45 and 60 minutes. All interviews were audio-recorded with participant consent. The participants consent forms and the complete questions were appended to Appendices H and I, respectively. All the feedbacks from the Delphi Experts was further analysed using thematic analysis (Nowell et al., 2017) and became the main input for the construction of questionnaire in Delphi II section. The data collection and data analysis of Delphi I are further discussed in Chapter 4.

3.4.6 Main reference for Delphi II Questionnaire; MS ISO45001

The feedback from Delphi I was transcribed and analysed using thematic analysis (Nowell et al. 2017). The input was useful in developing the questionnaire for Delphi II. In addition, *Malaysian Standard (MS) ISO 45001:2018 Occupational Health and Safety Management Systems: Requirements with Guidance for Use* and *Malaysian Standard MS1722 OSHMS* were used as main references to make it more practical, reliable, and suit the requirements of safety aspects in the mining industry. This Standard is a new standard that started in 2018 and has already been applied to various industries in Malaysia. However, this is still new and has just started to be practised in the Malaysian mining industry. Previously, the OSH aspects in the mining industry were used and applied to all the requirements set up by the Department of Safety and Health Malaysia (DOSH), which was named the Occupational Safety and Health Worksheet Assessment (OSHWA). Moreover, the MS ISO 45001:2018 was recommended by one of the validators for the questionnaire survey of Delphi II: He has extensive experience in safety aspects and is known as a Safety Advisor and Technical Consultant for various industries in Malaysia, such as oil and gas, manufacturing, and electronic.

3.4.7 Reliability and Validation

By submitting the instruments to the validators to validate the questionnaire used in Delphi II, the content of these survey instruments was verified. The expertise of validators is highlighted in Table 3.10. Appendix M and Appendix N showed the appointment letter as validator for questionnaire and validation form for Delphi II.

Table 3.10 Background of Validators

Validator	Position	Working experience (years)	Expertise
V1	Senior Lecturer	19	Designing questionnaire
V2	Safety Advisor cum Technical Consultant	20	Safety Culture, OSH, Designing questionnaire
V3	EHS Superintendent	15	OSH, Designing questionnaire

These individuals were asked to check the following:

a) Make sure the meaning of each statement is clear and easily understood.
b) Suggest any changes that might improve how the statements are written.
c) Suggest items to add or delete from the survey to get better information.
d) Suggest ways to improve the appearance and format of the survey.

The instruments were improved as a result of the suggestions of the validators. Issues of reliability and validity must be considered when doing any research project. The degree to which a technique consistently generates comparable outcomes under the same conditions on all occasions is referred to as reliability. There is no evidence that the Delphi technique is reliable: in other words, would identical information be provided to two or more panels and get the same results? To solve this problem, Lincoln and Guba's (1985) qualitative study criteria could be used to ensure that reliable interpretations of the findings are produced. Credibility (truthfulness), application, auditability (consistency), and conformability are the four key issues that the criteria are focused on.

The Delphi is based on the belief that there is safety in numbers (i.e., several people are less likely to arrive at a wrong decision than a single individual). A reasoned argument, in which assumptions are challenged, helps to reinforce decisions and improve validity. Pressures for prediction convergence (Hill and Fowles, 1975) diminish the Delphi's forecasting power and pose a threat to validity. On the other hand, the use of participants with knowledge and interest in the issue may help to improve the Delphi's content validity (Goodman 1987), and the use of multiple rounds of the questionnaire may help to improve the concurrent validity. Nonetheless, it must be mentioned that response rates will ultimately affect the validity of the results.

The Delphi study's success is also determined by the quality of the questionnaire. Since the questionnaire is more time-consuming than a standard survey, Okoli and Pawlowsk (2004) proposed that no single quiz should take more than 30 minutes to complete. The researcher submitted the questionnaire to three validators in order to check the quality of the questionnaire and address the potential drawbacks of Delphi. Moreover, the study used a 5-point Likert’s scale for the questionnaire, and therefore, Cronbach’s Alpha is the most common form to test the measurement scale attitude or internal consistency of the questionnaire with three, five, or seven choices (Tavakol and Dennick, 2011).

3.4.8 Data collection and analysis

The main purpose of data collection and analysis was to investigate the influencing factors of safety culture in three dimensions; psychology, situational, and behavioural. In a Delphi study, data analysis utilised both qualitative (Delphi I) and quantitative (Delphi II). For Delphi I, which involves asking open-ended questions to elicit responses, was utilised. The interview session was conducted based on the availability of Delphi experts. The session was conducted in March and April 2021.

The open-ended question guidelines were suggested by Dillman, Smyth, and Christian (2009), as follows: *"Specify the number and type of responses desired in the question stem"* and *"design the answer spaces to support the type and number of responses desired"*. The Delphi I survey asked respondents about safety culture practises and awareness in the Malaysian mining industry. The experts were also asked about influencing factors for establishing a good safety culture in the Malaysian mining industry. Later, the data were analysed using thematic analysis, as suggested by Nowell et al. (2017). The way to determine consensus on Delphi I for open-ended questions is shown in Table 3.11. To avoid biasness for online session, several actions was taken such as make sure participants react within the time frame given by sending them prompt reminders and instructions (Brady, 2015) and explain to participants the importance of their responses and the intended objectives of the study (Brady, 2015).

For Delphi II, the questionnaire survey of safety culture was designed and developed according to the themes and subthemes created using thematic analysis (Nowell et al., 2017) in Delphi I. Once the questionnaire was sent via email to the Delphi experts, each member had approximately two weeks to respond. The researcher combined the topics into a list containing a 5-point Likert scale, as presented by Allen and Seaman (2007). The instructions for filling out the surveys were stated clearly and plainly on the survey instruments. The second-round surveys were used for the purpose of attaining consensus of the panel of experts (Thaangaratinam and Redman, 2005). The Delphi experts responded to a questionnaire, and statistical analysis was used to analyse all responses.

Several measures were taken into consideration to address bias resulting from the two-week interval between rounds in the Delphi technique, including;

i. Prompt Communication and Reminders: Make sure participants react within the time frame given by sending them prompt reminders and instructions (Brady, 2015).

ii. Inform Participants: Explain to participants the importance of their responses and the intended objectives of the study (Brady, 2015).

iii. Diverse Expert Panel: To mitigate personal biases, assemble a unique panel of experts (Murphy and McHugh, 2005).

iv. Anonymity and Neutral Summarization: To avoid bias and influence, keep comments anonymous and make sure that summaries are impartial (Linstone and Turoff, 2002).

v. Consistent Data Collection: Ensure that the survey instruments remain the same in each round to prevent the introduction of new variables (Hsu and Sandford, 2007).

3.4.9 Reporting results: Determination of Consensus for Delphi Technique

There is no consistent method for reporting findings in Delphi surveys (Schmidt 1997), and a review of the literature revealed that a variety of approaches have been utilised. For this study, the Delphi I involved an interview session, and the feedback was analysed using thematic analysis, where the themes and sub-themes were created (Nowell et al., 2017).

For Delphi II, the questionnaire survey was involved. Previous scholars used graphical depiction and textual presentation of statistical results, showing central tendencies, variance, and ranks (Chocholik, Bouchard, Tan, and Ostrow, 1999). However, there are various methods that can be used to determine the consensus in the Delphi Technique for questionnaires using 1 to 5, 1 to 7, or 1 to 10 of Likert's scale. In addition, Hasson, Keeney, and McKenna (2000) note that in order to present data regarding the group judgements of respondents, measures of central tendency (means, median, and mode) and level of dispersion (standard deviation and inter-quartile range) are the main statistics used in Delphi studies. Table 3.11 shows the determination of consensus for the Delphi Technique (quantitative) as suggested by previous scholars.

Table 3.11 Determination of Consensus for Delphi Technique

Delphi's Round	**Analysis method**	**Description to achieve consensus**	
Qualitative (Interview)	1. Based on statement	Consensus is achieved if (Stitt-Gohdes and 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	i. At least 51% achieve agreement on each response (McKenna, 1994). ii. An increase in percentage agreements for each round (Holey, Feeley, Di, and Whittaker, 2007)	
Quantitative (questionnaire survey)	Analysis method	Description to achieve consensus	
		5-point Likert scale	10-point Likert scale
	1. Based on Median	According to Lamers Cuypers, Garvelink, de Vries, Bosch, and Kil (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. Median 3: agreement on a statement's disagreement.	According to Aigbavboa (2015); i. Strong consensus: median 9-10, ii. Good consensus: median 7-8.99 iii. Weak consensus: median $\leq$ 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 (2015); i. Strong consensus - interquartile deviation (IQD) ≤ 1 and $\geq 80\%$ (8-10); ii. Good consensus - IQD$\geq 1.1 \leq 2$ and $\geq 60\% \leq 79\%$ (6-7.99); iii. Weak consensus - IQD$\geq 2.1 \leq 3$ and $\leq$ 59% (5.99).

Source: Stitt-Gohdes et al. (2004), Holey et al. (2007), Lamers (2016), Aigbavboa (2015), Rayens and Hahn (2000), Holey et al. (2007), Spinelli (1983)

Based on Table 3.11, the analysis of Delphi I was based on statements (Stitt-Gohdes and Crews, 2004) and percentage responses (McKenna, 1994; Holey, et al., 2007) to determine consensus among Delphi experts. For the analysis of Delphi II, the median (Lamers et al., 2016), standard deviation, frequency distribution (Raskin, 1994), and Interquartile Deviation (IQD) (Rayens and Hahn, 2000) were used to determine the consensus or agreement on each statement. Most of these previous techniques were highly acceptable for quantitative analysis (Lamers et al., 2016).

In this study, Delphi's responses were analysed using percentage responses, as discussed in further detail in Section 4.2.2. For the Delphi II questionnaire survey, a 1- to 5-point Likert scale was used, which involved the median, standard deviation, and IQD analysis as discussed in Sections 4.3.4 to 4.3.6.

3.4.10 Ethical consideration

All the Delphi experts do not meet face-to-face, so they can present and react to ideas without being influenced by the identities or pressures of others (Goodman, 1987). One of the aspects that distinguishes this method from other consensus methods, according to reviews, is anonymity (nominal group technique). Sumsion (1998) recommends a response rate of 70% for each round in order to preserve the rigour of this technique. To achieve this, the researcher must know the identities of respondents and non-respondents. As a result, achieving complete anonymity poses challenges. The phrase 'quasi-anonymity' refers to the fact that respondents will know the researcher and even each other, yet their judgements and opinions will remain completely anonymous (McKenna, 1994).

3.5 Stage 3: Analytical Hierarchy Process (AHP)

AHP was first introduced by Myers and Alpert in 1968 and later developed by Saaty (1977). The AHP is a powerful multi-criteria decision-making tool that accommodates different criteria that influence a decision to varying degrees. The AHP can enable decision-makers to represent the interaction of multiple factors in complex and unstructured situations. It is based on pair-wise comparisons between criteria/sub-criteria on each level with respect to the goal of obtaining the best alternative selection

(Saaty, 1980). The AHP was used to solve underground mining method selection (Gupta and Kumar, 2012) and was also useful to study the risk assessment of occupational groups working in open pit mining (Kasap and Subaşı, 2017),

3.5.1 Justification on selection of AHP Method

Multi-criteria decision-making (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. There are many tools available for decision-making, like the Analytic Network Process (ANP), Data Envelopment Analysis (DEA), Aggregated Indices Randomization Method (AIRM), Weighted Product Model, and (WPM) Weighted Sum Model (WSM). However, in this research, AHP has been chosen due to its wide application in mining industry research, as shown in Table 3.12.

Table 3.12 Application of AHP for the research in mining industry

Delphi's Derivatives	**Type of Mine/Country**	**Ref**
Delphi-Analytical Hierarchy Process (AHP)	Coal/China	Guan, Shao, Gu, Ju, and Huang (2016)
	Coal/China	Geng, Chen, Wang, Liu, and Xu (2017)
	Coal/China	Xu et al. (2018)
	coal, iron ore, bauxite, lead–zinc, molybdenum, gold, fluorite, and graphite / China	Zhang, Li, and et al. (2020)
Fuzzy Delphi -AHP	Coal/China	Wu, Zuo, and Fang (2011)
	Phosphate/ China	Shang, Yin, Li,, Jiang, Kang, Liu and Zhang (2015)
	Coal/ Iran	Saffari et al. (2017)
	Coal/China	Yang, Li, Pei, Qiao, and Wu (2018)
	Coal/China	Sun and Xue (2019)
	Coal/ Iran	Mikaeil, Gharahasanlou, and Jafarpour (2020)
Delphi -AHP- SPA	Coal/China	Chong, Yi, and Heng (2017)

Source: Guan et al. (2016), Geng et al.(2017), Xu et al. (2018), Zhang et al. (2020), Wu et al. (2011), Shang et al. (2015), Saffari et al. (2017), Yang et al.(2018), Sun and Xue (2019), Mikaeil et al.(2020), Chong et al.(2017)

Furthermore, in this research work, AHP was found to be more suitable as it facilitates measuring consistency of results and gives the possibility to change the decisions if they are not satisfactory or fail in the consistency test. Moreover, AHP is suitable for various types of problems, management, corporate policy and strategy, public policy, and political strategy and planning (Albayrak and Erensal, 2005; Aldlaigan and Buttle, 2002). Moreover, researchers chose AHP due to its benefits, as highlighted by Kasap and Subaşı (2017);

- ensures accurate decisions are made by ensuring the decision-making process is formal and systematic,
- allows for carrying out sensitivity analyses of the results,
- practical method which makes it possible for the decision-making based on identified objective,
- has a design that simplifies complicated problems,
- allows for involving both quantitative and qualitative data in the decision-making process,
- for a decision problem,
- allows for measuring the consistency level of the decision maker's judgments, which is suitable for use in group decisions
- decision-making with AHP might involve taking qualitative values into account, as well as quantitative ones.
- AHP is based on the principle that knowledge and experiences are valuable as data are taken into consideration in decision-making.

3.5.2 Stages of AHP Method

The stages of AHP process is summarised in Figure 3.6.

For Stage 1: The decision-making problem is defined and divided into sub-problems in a hierarchical order. In other words, a model that shows the fundamental criteria of the problem and the relationships among these criteria is formed.

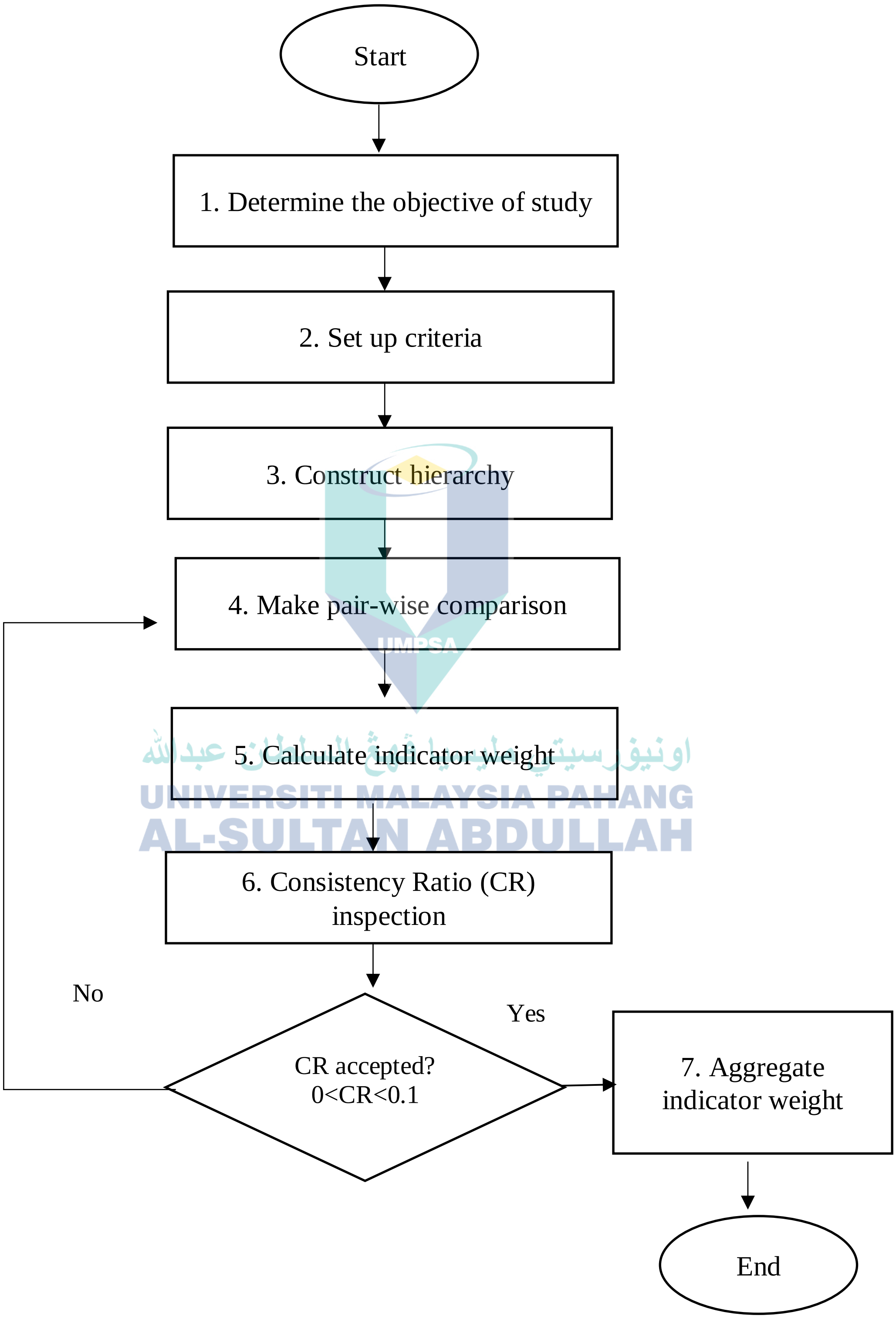


Figure 3.6 Process flow of AHP Process

Source: Saaty (1980)

Stage 2 to Stage 4: A comparison matrix is formed by making a pairwise comparison between the factors. At this stage, two factors are compared with each other according to their relative importance based on the decision maker's judgement (pairwise comparison). The relative importance values are determined by using the 1~9-point scale developed by Saaty (2005), as shown in Table 3.13. In the comparison matrix (A), n represents the number of criteria to be compared, and a_{ij} shows the importance of i property in comparison with j property.

$$\mathbf{A} = (a_{ij})_{n\times n} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \tag{3.1}$$

When aii > 0, there are aij ¼ 1/aji and aii ¼ 1 relationships between the matrix elements. For example, if the first factor is seen as more important than the third factor, the person making the comparison matrix scores it as 3. In the opposite case, when the person compares the first row, third column component (i = 1, j = 3) of the third factor being favoured over the first one in terms of importance, the first row, third column component of the comparison matrix receives a score of 1/3. On the other hand, if the first and third factors are regarded as equally important, then the component will receive a score of 1. Comparisons are made for the values remaining above the diagonal of the matrix, all of which are 1. For the components remaining below the diagonal, however, Equations (3.1) and (3.2) were used. Table 3.13 shows the pair wise comparison scale for AHP.

$$a_{ji} = \frac{1}{a_{ji}} \tag{3.2}$$

Table 3.13 The pair wise comparison scale

Intensity of importance	**Definition**	**Explanation**
1	Equal importance of both elements	Two elements contribute equally to the property
3	Moderate importance of one over the other	Experience and judgment slightly favour one element over the other
5	Strong importance of one element over the other	Experience and judgement strongly favours one element over the other
7	Very strong importance of one element over the other	An element is strongly favoured and its dominance is demonstrated in practice
9	Extremely importance of one element over the other	The evidence favouring one element over the other is one of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values	When compromise is needed

Source: Saaty (1980)

Stage 5: The percentual distribution of the importance of factors is determined. The comparison matrix displays the relative importance of factors over each other with certain logic. However, in order to determine the individual weights of these factors of the whole, that is, the percentual distribution of importance, the B column vector with the n-element is formed by using the column vectors constituting the comparison matrix

$$Column\ Vector\ B_i = \begin{bmatrix} b_{11} \\ b_{21} \\ b_{31} \\ \vdots \\ . \\ b_{n1} \end{bmatrix} \tag{3.3}$$

Equation (3.4) is used to calculate B column vectors.

$$b_{ji} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{3.4}$$

The weights of all the assessment factors within the whole, i.e., the B column vectors, are generated. When the n B column vector is gathered in the form of a matrix, the C matrix below is formed.

$$\mathbf{C} = \begin{bmatrix} c_{11} & c_{12} & \cdots & c_{1n} \\ c_{21} & c_{22} & \cdots & c_{2n} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ c_{n1} & c_{n2} & \cdots & c_{nn} \end{bmatrix} \tag{3.5}$$

The percentual distribution of importance, which shows the important values of factors, can be obtained by using the C matrix. For this purpose, as shown in Equations (3.6) and (3.7), the arithmetic mean of the row elements that make up the C matrix is calculated, and the W column vector, called the priority vector, is obtained.

$$w_i = \frac{\sum_{j=1}^{n} c_{ij}}{n} \tag{3.6}$$

The W vector is shown below

$$W = \begin{bmatrix} w1 \\ w2 \\ w3 \\ \vdots \\ \cdot \\ wn \end{bmatrix} \tag{3.7}$$

The relative importance of each factor is determined when each factor is assessed together.

Stages 6 to 7: The consistency of factor comparisons is measured. Although AHP has an internally consistent system, the authenticity of results depends on the consistency of the one-to-one comparison among factors made by the decision-maker. AHP suggests a process to measure the consistency of these comparisons. It provides an opportunity to test the consistency of the priority vector and therefore one-to-one comparisons among the factors by means of the resulting Consistency Ratio (CR). In AHP, the CR calculation is based on the comparison of the number of factors and a coefficient called the Fundamental Value (λ). The D column vector is obtained by the matrix multiplication of comparison matrix A with priority vector W, in order to calculate λ.

$$\mathbf{D} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \text{x} \begin{bmatrix} w_1 \\ w_2 \\ \cdot \\ \cdot \\ \cdot \\ w_n \end{bmatrix} \tag{3.8}$$

As defined in Equation (3.8), the fundamental value of each assessment factor is obtained by dividing the corresponding elements of the resulting D column vector by the W column vector (Equation (3.7) showing the fundamental value of comparison (λ). (Equation (3.10)). Finally, the arithmetic mean of these values.

$$E_i = \frac{d_i}{w_i} \qquad (i = 1,2, \ldots \ldots n) \tag{3.9}$$

$$\lambda = \frac{\sum_{i=1}^{n} E_i}{n} \tag{3.10}$$

After λ is calculated, the Consistency Indicator (CI) can be generated through Equation (3.11).

$$CI = \frac{\lambda - n}{n - 1} \tag{3.11}$$

In the final stage, CR is obtained by dividing CI by the standard correction value, which is also called the Random Indicator (RI), as shown in Table 3.14 (Equation 3.12)

$$CR = \frac{CI}{RI} \tag{3.12}$$

The calculated value of CR, less than 0.10, indicates that comparisons made by the decision-maker are consistent. On the other hand, a CR value greater than 0.10 shows a calculation error in AHP or the inconsistency of the decision-maker in comparisons (Saaty, 1980).

Table 3.14 Average Random Consistency (RI)

Size of Matrix	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Random of Consistency	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty (1980)

3.5.3 Selection Criteria for AHP

The participants for AHP were selected based on the same criteria as Delphi experts, as shown in Table 3.16, who have extensive experience in mining operations, mine safety, and understand on safety culture. The participants must also have at least 10 years of working experience in the mining industry.

3.5.4 Development of a Questionnaire: A Quantitative Study

The AHP approach was applied to build a questionnaire survey that used a pair-wise comparison to evaluate the prioritisation of safety culture factors. The questionnaires were provided to five specialists in mining operations and safety, and they were allowed two weeks to complete them. The questionnaire survey received a 100% response rate.

According to Saaty (2015), there are no pre-set standards for determining the permissible sample size of experts in AHP analysis. Unless political expediency necessitates the use of multiple judges from various constituencies, one experienced judge may be adequate. As most respondents were unfamiliar with the AHP approach, the researcher provided a full explanation of the survey's purpose and AHP's applicability. Appendix Q and Appendix R included the participant sheet and AHP questionnaire survey. The respondents were asked to compare the importance of two paired factors and rate the scale of importance of the chosen component, as shown in Table 3.15.

The development and design of questionnaire was based on the influencing factors for psychological, situational, and behavioural safety culture obtained from analysed results of Delphi I and Delphi II. The aim of AHP study was to prioritise each factor as one of the highest influencing factors in constructing safety culture in the Malaysian mining industry. The AHP questionnaire consists of four main parts, which are;

i. Main criteria of safety culture: psychological, situational, and behavioural dimensions
ii. Psychology dimension Sub-Criteria: 10 questions
iii. Situational dimension Sub-Criteria: 45 questions
iv. Behavioural dimension Sub-Criteria: 36 questions

The example of AHP questionnaire is shown in Table 3.15 while a full set of AHP questionnaire was appended in Appendix R.

Table 3.15 Example of AHP questionnaire for Main Criteria of Safety Culture

Part 1: Main Safety Culture Criteria

1.Psychological : Refer to the "How People Feel" for individual and group values, attitudes and perception about safety (Cooper, 2000)
2.Situational : Refer to "What Organizational Has" including policies, regulation, organizational structure and management systems (Cooper, 2000)
3.Behavior : Refer to "What People Do" such as safety related actions and behaviour, safety leadership (Cooper, 2000)

Criteria A	Left hand side (LHS) is more important than Right hand side (RHS)								Equal	RHS is more important than LHS								Criteria B
Psychological	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Situational
Psychological	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Behavioural
Situational	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Behavioural

Source: Cooper (2000)

3.5.5 Validation of AHP Questionnaire

The content of the AHP Questionnaire was validated by a well-known Professor from one of the Institutes of Higher Learning Education in Malaysia with extensive experience in AHP. He helped in this study by ensuring the format and structure of the questionnaire were in good condition. The correction had been made according to his recommendation. The email invitation and appointment letter of the professor as validator for AHP were appended in Appendix S and Appendix T respectively.

3.6 Stage 4: Focus Group Discussion (FGD)

3.6.1 Validation for Qualitative Findings

Focus group discussions are widely employed as a qualitative strategy to comprehend social topics in depth. Instead of using a statistically representative sample of a larger population, the strategy seeks to collect data from a deliberately chosen group of people (Nyumba, Wilson, Derrick, and Mukherjee, 2018). The FGD approach was used because it offers flexibility in gathering ideas and new themes during the discussion and gives participants the chance to express their opinions, understandings, and varied viewpoints (Stewart and Shamdasani, 2017; Kitzinger, 2005).

The FG talks were structured in accordance with the methodology outlined in Krueger (2014) and Nyumba et al. (2018). As a result of restrictions brought on by the COVID-19 epidemic, FGD in this study was conducted online via the Google Meet platform. There are benefits and drawbacks to this strategy. Additionally, it makes it easier to record sessions and offer participants visual information. It also reduces the time consuming aspect of travelling and the cost of renting a suitable meeting room. On the other hand, unexpected technical issues and a poor internet connection could make the discussions take longer (Stewart & Shamdasani, 2017). In this study, Objective 5 was to validate the proposed safety culture framework. The validation process was conducted by interviewing the FGD panels and allowing them to express their opinions and validate the influencing factors of safety culture in the Malaysian mining industry obtained from previous findings in Delphi I and Delphi II.

3.6.2 Criteria for FGD Panels

According to Nyumba et al. (2018), to identify and recruit panels for FGD, it must follow the following criteria: (i) ensure homogeneous composition (gender, education, language, etc.), and (ii) the number of participants is 4 to 15 persons. In this study, the main criteria set by researcher was that the panel must have extensive experience in mining industry or Occupational Safety and Health (OSH), as shown in Table 3.16. Appendix V and Appendix W showed the example of email invitation and appointment letter for FGD panels respectively.

Table 3.16 Criteria for selection of FGD Panels

Criteria	**Background of FGD Panels**		
	Mining industry	**Government agencies**	**OSH field**
Working experience	At least 10 years and above for each respective sector		
Area of expertise	Mining operation or Mineral development or Mine Safety or Mining policy or Mineral R&D	Mining operation or Mineral development or Mining policy	OSH, especially safety culture practices and implementation Organizational behaviour
Example of Position	Mine Owner/Operator, Top Management (CEO/ President/Vice President) Mining Consultant Mining Manager SHE Mine Manager Mining Safety Officer	Director of Mineral Development, Enforcer/ Mine Inspector	SHE Manager, Safety Officer, Mine Safety Engineer

3.6.3 Flow for FGD

According to Nyumba et al. (2018), the flow chart of the steps of the focus group discussion technique consists of four main steps: (1) Research design, (2) Data collection, (3) Analysis, and (4) Results and reporting, as shown in Figure 3.7.

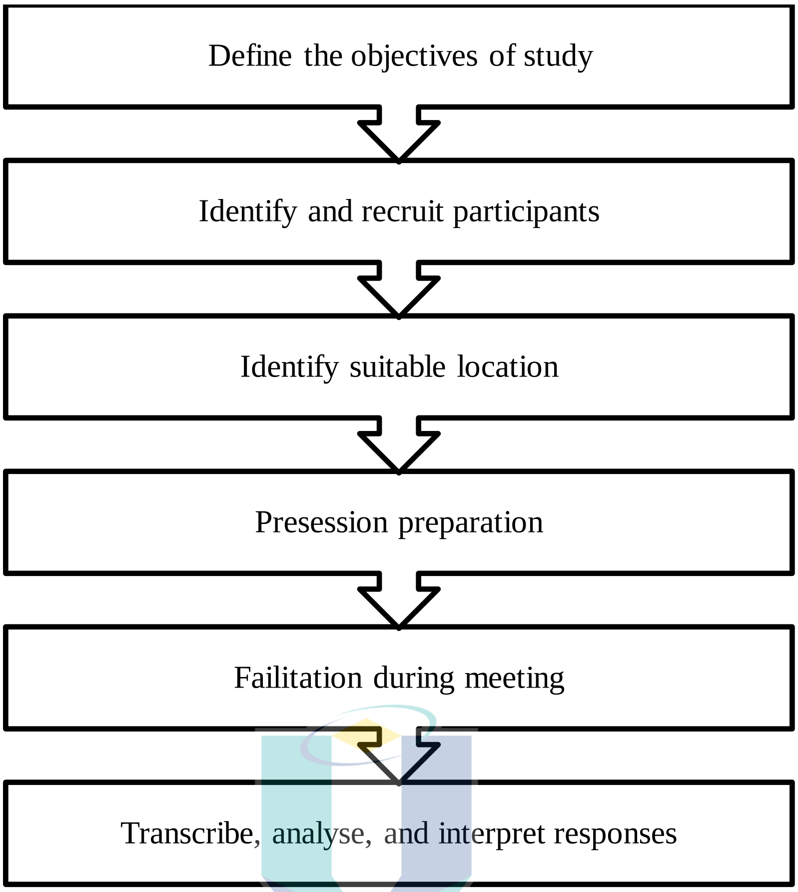


Figure 3.7 Flow chart of the steps of the focus group discussion technique

Source: Nyumba et al.(2018)

3.7 Stage 5: Case Study at a volunteered mining company

The case study or research field was conducted to validate the findings of Delphi I, Delphi II, and Focus Group Discussion (FGD) by proposing the influencing factors of the safety culture framework at a selected mining company. An observation and questionnaire survey were conducted to validate those findings. The email was sent to the mining company, and the volunteered company was selected as a case study.

3.7.1 Criteria selection for the case study

The purpose of the case study at the mining company was to validate findings from Delphi I, Delphi II, AHP, and FGD. The criteria for a mining company are as follows;

i. Legal and registered mining company (either a small or large mining operation)
ii. Volunteered to participate in this research

iii. Followed the regulations or rules as instructed by the Department of Occupational Safety and Health (DOSH Malaysia) and local authorities

iv. Located in Malaysia

3.7.2 Guidelines to Conduct Safety Culture Study at a Mining Company

To conduct observation at the mining company, the researcher used the checklist as enforced by the Department of Safety and Health Malaysia (DOSH). OSHWA or known as Occupational Safety and Health Work Assessment is a self-regulated assessment for mine owners to evaluate their safety and health at the mine workplace. In general, OSHWA consists of two parts, as shown in Table 3.17.

Table 3.17 OSHWA Physical and Documentation Audit

Component	**Part**	**Subpart**
Physical Audit	A. Hazardous Chemicals	1. Labelling
		2. Risk control
		3. Warning signs
		4. Storage
		5. Safety Data Sheet (SDS)
	B. Noise Management	1. Risk control
		2. Warning signs
	C. Ergonomic	1. Employers identify ergonomic problems
		2. Control measures
	D. Workplace Assessment	1. Exit signs and emergency lights
		2. A path without obstacles
		3. Arrangement of items in order
		4. Verification of the safe structure of the work platform/load
		5. Marking of the work area
		6. Perfect condition of work floor, platform, and stairs
		7. The open edge is blocked
		8. Holes and floor openings are closed/ fenced
		9. Cleanliness and tidiness of the work area
		10. Control the risk of working at a height of more than 10 feet
		11. Risk control from the aspect of the work environment
	E. Plant and Machinery Management	1. Risk control
		2. Safe Work Procedures (SOP)
		3. Certified Machinery Registration Number
		4. Warning signs
		5. Electrical safety
	F. Welfare	1. Toilet facilities
		2. Place/Rest room (Prayer room)
		3. Clean drinking water facilities
		4. Leisure and social facilities

Table 3.17 Continued

Component	Part	Subpart
	G. Emergency Response Plan (ERP)	1. First Aid Box/First Aids Box 2. Fire-fighting equipment 3. Assembly point area
Documentation Audit	A. Policy	1. Safety and Health Policy of company. 2.Employee participation and understanding on safety and health policy
	B. OSH Organising	1. Establishment of Safety and Health Committee 2. Safety and Health Team Meeting 3. Accident investigation 4. Person in charge / emergency contact
	C: Training	1. Training plan 2. Implementation (On-the-job training, Emergency Response Team, Chemical- handling training, Noise-handling training 3.Refresher training 4. Evaluation
	D. Record Keeping	1. Risk Assessment) 2. Hazardous chemicals (CHRA report, storage, MSDS) 3. Noise Exposure Management (noise risk assessment and audiometric test) 4. Management on heavy duty machinery 5. Emergency response plan (ERP) 6. Contractor management 7. NADOPOD 8. Personal protective equipment (PPE)

Source: OSHWA (2022)

3.8 Concluding Remarks of Chapter 3

This study used a sequential mixed-method design to investigate the influencing factors of psychological, situational, and behavioural dimensions to establish a safety culture framework in the Malaysian mining industry. The main methods applied in this study are summarised below;

i. Preliminary study: (Open-ended interview (Qualitative)
ii. Delphi I: Open-ended interview (Qualitative)
iii. Delphi II: Questionnaire Survey (Quantitative)
iv. AHP method: Questionnaire Survey (Quantitative)
v. Focus Group Discussion (FGD): (Validation of qualitative findings/ proposed framework)
vi. Case study: (Validation of proposed framework)

CHAPTER 4

RESULTS AND DISCUSSION

This chapter highlights the findings and discussion on the main findings of the preliminary study: Delphi Techniques, Analytical Hierarchy Process (AHP) method, and Focus Group Discussion (FGD) on safety culture in the mining industry. The presentation flow of results in this section is illustrated in Figure 4.1.

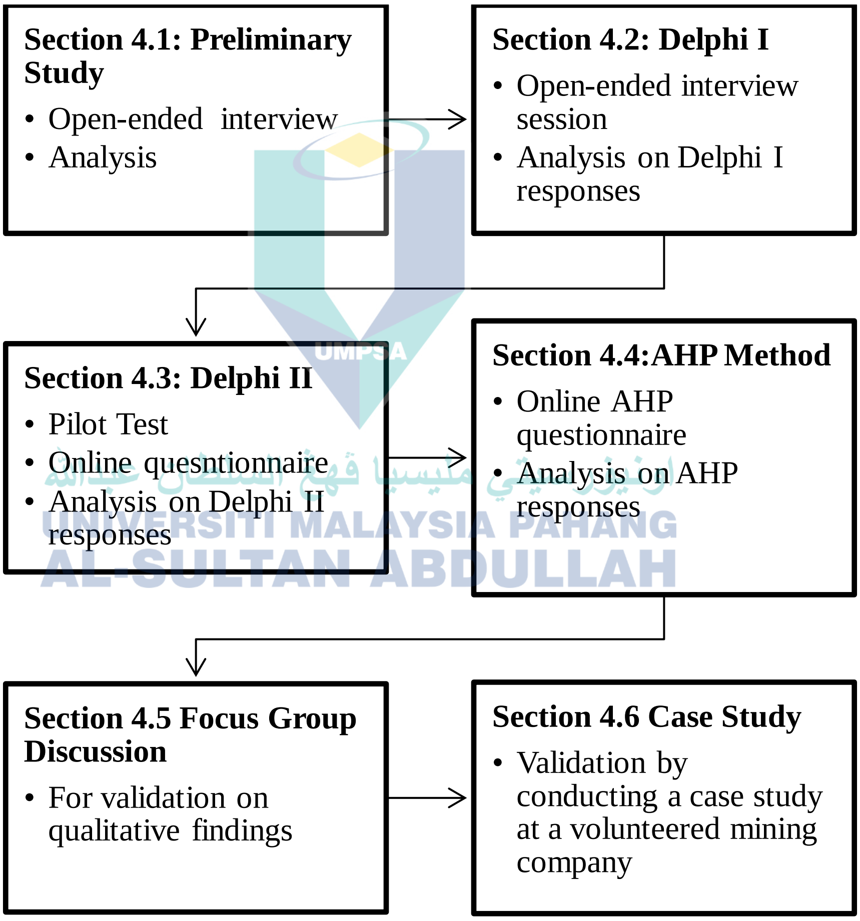


Figure 4.1 Presentation flow of results and discussions

Table 4.1 shows the number of mining experts, validators, and timeline for the safety culture study. For Stage 2, Delphi I and II used the same mining experts, meanwhile for Stages 1, 3, 4, and 5, different mining experts were involved.

Table 4.1 Number of Mining Experts, Validators and Timeline for the Safety Culture Study

Stage	Main Research Method	Number of Mining Experts Involved	Number of Validators	Timeline
1	Preliminary Study on Safety Culture	6	-	Dec 2020-February 2021
2	Delphi 1: Open-ended Interview session	21	-	March 2021 to May 2021
	Delphi II: Questionnaire on Safety Culture	18 *(used same experts from Delphi I)*	3 validators from industries	Jun 2021 to July 2021
3	Analytical Hierarchy Process (AHP)	5	1 Professor	October 2021
4	Focus Group Discussion (FGD)	5	5	13 January 2022
5	Case study at a volunteer mining company	3	Same validators in Delphi II	August 2022 to Nov 2022

4.1 Results of the Preliminary Study- Interview session with Mining Experts

In this section, the preliminary study was conducted by inviting the mining experts to obtain their perspectives and experiences on safety culture in the mining industry in Malaysia.

4.1.1 Main Purpose of the Preliminary Study

The preliminary study was conducted as a basis of research to obtain the perspectives and experiences of mining experts in order to achieve Objectives 1 to 3. These are as follows;

1. To investigate the influencing factors of psychological dimensions on the safety culture prevailing in the mining industry in Malaysia.

2. To investigate the influencing factors of situational dimensions on the safety culture prevailing in the mining industry in Malaysia.

3. To investigate the influencing factors of behavioural dimensions on safety culture

prevailing in the mining industry in Malaysia.

To achieve Objectives 1, 2, and 3 in this study, a preliminary study was conducted to investigate and understand the current status of safety culture awareness and practise in the Malaysian mining industry by interviewing mining experts in Malaysia. The important information to execute the preliminary study and the findings of the preliminary study were appended to the supporting document upon request.

4.1.2 Ethical Consideration and Consent

All consent forms from the respondents were submitted to the researcher for record purposes; an example of the consent form is shown in Appendix A.

4.1.3 Data collection

The researcher sent an email invitation to the six mining experts to obtain their permission to participate in this study. The examples of email invitations and appointment letters for the preliminary study were appended in Appendices B and C, respectively. Once the experts agreed, appointment letters (UMP.17.04/13.11/1/7) for participation in this study were sent via email to selected six mining experts, who had agreed to share their experience on safety culture in the mining industry. Prior to the start of the interviews, all experts provided their oral consent. The researcher informed the participants of the objectives of the study and guaranteed the confidentiality of their detailed personal backgrounds. The possibility of withdrawing from the study at any time was also ensured.

A qualitative, open-ended interview session for the preliminary study was conducted using the online Google Meet platform between December 2020 and February 2021. The respondents received a reminder email from the researcher about the interview. A date and time for the interview were set and agreed upon beforehand by both parties, the interviewer and interviewee, depending on their availability. All interviews were conducted in English and Malay and auto-recorded. The researcher conducted the interviews with the help of an interview guide, which consists of ten questions as appended in Appendix D. Open-ended questions employed in the study aimed to obtain the perspectives and experiences of the respondents related to safety culture in the Malaysian mining industry. The duration of the individual interviews was between 30 and 45 minutes, with an average of 35 minutes. Table 4.2 shows the background of the mining experts for the preliminary study.

Table 4.2 Background of the mining experts for the preliminary study

Code Name	Position	Years of Experience in Mining Industry
P1	Former Deputy Director in government mining sector	42 years
P2	Technical Consultant in mining	48 years
P3	Mining Consultant cum gold mine owner	27 years
P4	Safety and Health Officer	11 years
P5	Assistant Director (Mines & Quarry)	14 years
P6	Contract Mining Manager cum former Safety and Health Officer in mining	20 years

4.1.4 Analysis of the Preliminary Study

The responses obtained from six mining experts were transcribed, analysed, and summarised. The collected data were analysed by the researcher using thematic analysis (Braun and Clarke, 2006), a method that arguably offers an accessible, theoretically flexible, and straightforward approach to analysing qualitative data (Mcleod, 2017). The analyses consisted of several steps: the initial text was assessed several times and discussed at length, with the intention of familiarising oneself with the collected data, followed by assigning preliminary codes to the text to describe the content that reflected the key messages of the interviews. The next step was searching for patterns or themes in the preliminary codes across different interviews. The identified themes were later reviewed, defined, and named.

The output of the interview session mainly described the mining experts' views and experiences in the mining industry and the significance of inculcating safety culture in the mining industry in Malaysia. The overall theme on the "current status of safety culture awareness in the Malaysian mining industry" was generated and segmented into three themes and eight sub-themes, as demonstrated in Figure 4.2. Each of the themes and its subsequent sub-themes are explained below**:**

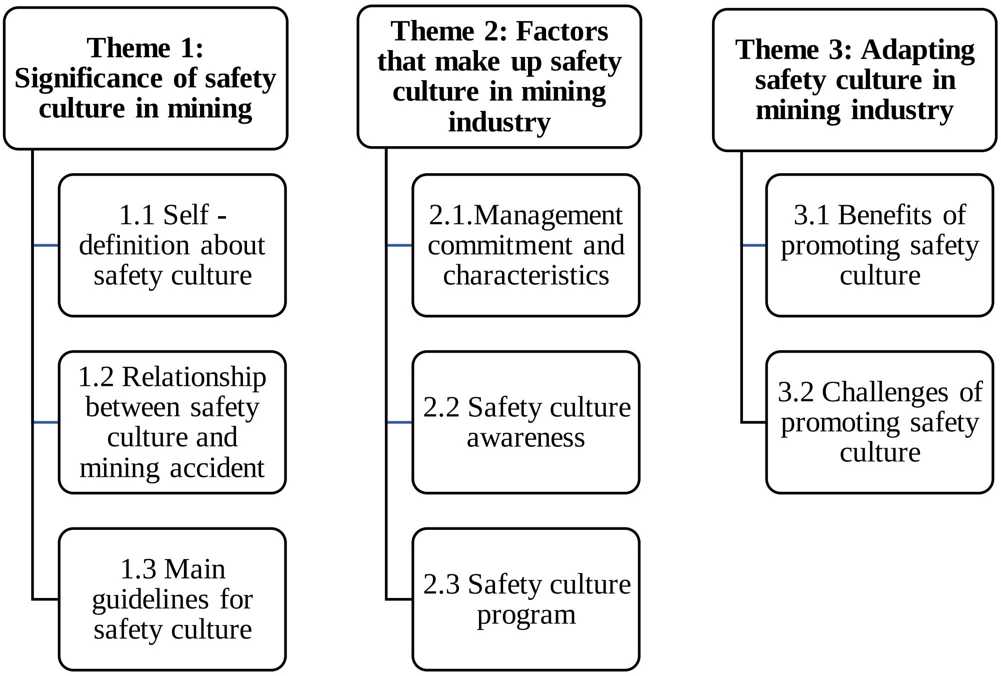


Figure 4.2 Themes and sub-themes on safety culture in the Malaysian mining industry

4.1.5 Theme 1: Significance of safety culture in mining

All mining experts acknowledged the significance of promoting a good safety culture in the Malaysian mining industry. This theme generated three sub-themes:

(i) 1 Self-definition about safety culture

Respondents expressed their understanding and perspective on the definition of safety culture in the mining industry in Malaysia.

> *"Safety culture in mining industry should consists of five main elements:*

- *Value — we set objective and target and built from there;*
- *Attitude — open-minded, honest communication;*
- *Perception — it is a team effort and not a one man's job, every level of management share responsibility and can be accountable for;*
- *Competency — competent Safety Health Officer (SHO) and first aider, appointed Safety Health Committee (SHC) and Emergency Response Team (ERT); and*

- *Patterns of behaviour — complying with safety rules and regulation, safety reminder from time to time, instruction when necessary."* (P4)

> *"A safety culture is a value and priority that is the responsibility of all individuals in an organisation to other employees or the work environment which will bring results if done consistently. These values include personal responsibility, maintaining behaviour, communicating and raising awareness of safety issues, striving to learn more actively, yielding results if done consistently. These values include personal responsibility, caring for behaviour, communicating and raising awareness of safety issues, striving to learn more actively, adapting, and modifying behaviour based on experience through mistakes. Safety culture can also be defined as the way individuals in an organisation behave as a result of the influence of beliefs, practices, and attitudes."* (P5)

(ii) Relationship between safety culture and mining accidents

Respondents agreed that nowadays, safety culture plays an important role in preventing mining disasters or accidents. It has been implemented in various industries worldwide. Even though there has never been a large-scale mining disaster or mining accident in Malaysia, the importance of safety culture in mining industry cannot be denied, since mining activities has been considered as one of the high-risk jobs.

> *"Although the number of accident cases involving the mining sector reported is decreasing every year, but it does not mean that this aspect of safety culture has been successfully fully practiced. There are still cases of fatal accidents that occur in the mining area either involving the operation of machinery or motor vehicle accidents in the area of the mine work site. Investigations conducted by the department, found that the cause of the accident was due to the negligence of employees and indifference to the risk of accidents. The cause of such accidents gives the impression that the safety culture in the mining sector is still weak and needs to be improved."* (P5)

The mining expert (P4) also provided examples of unsafe acts and conditions that are common in the coal mine industry due to poor safety culture, as shown in Table 4.3. If no prevention or safety action is taken, it can lead to a mining accident and/or disaster.

Table 4.3 Examples of common unsafe acts and conditions at mine sites as listed by Expert P4

Unsafe act	***Unsafe condition***
1. Driver lorry not wearing proper personal protective equipment (PPE) *2. Machine operator not wearing proper PPE* *3. Parking lorry at side of the road* *4. Do not observe safe distance from front vehicle* *5. Do not observe safe distance from wheel loader at feeding area speeding/reckless driving* *6. Fail to lower lorry bucket jack on time*	*1. Additional storage at weighbridge area* *2. Working at thin bund surrounded with water bund slide* *3. Coal spillage dusty road* *4. Working under unconsolidated material water ponding* *5. Hole at access egress* *6. Canvas not properly tied* *7. Overnight parking outside premise overload* *8. Wildfire*

(iii) Main guidelines for safety culture in mining industry

Respondents agreed that there is no solid guideline, handbook, blueprint, or framework for safety culture in the mining industry in Malaysia. It could be helpful if the mining industry had its own safety culture framework or guideline. At this moment, all industries including mining will follow the Occupational Safety and Health 1994 (OSHA, 1994).

> *"Not clearly known. However, it is believed that multinational mining companies operating in the country, have absorbed elements of safety culture. These large - scale companies usually have international recognition in various aspects including in the security culture. Meanwhile, in 2015, the DOSH published an Action Plan for the Improvement of Occupational Safety and Health (OSH) in the Mining and Quarrying Sector. Among the improvement action plan strategies include introducing a safety culture at workplace." (P5)*

> *"OSHA 1994." (P1, P3, P6)*

There are also a few guidelines that directly touch on important safety aspects for the construction of safety culture in the mining industry, such as:

"Environmental Impact Assessment (EIA), Occupational Safety and Health Act (OSHA), Department of Environment (DOE) regulations, Waste Disposal Regulations, Mining Acts, Blasting of Quarries and Mine areas Laws, Mine Rehabilitation Funds and Plans." (P2)

"Occupational Safety and Health Act (OSHA 1994), Occupational Safety and Health (Use and Standard of Exposure Chemical Hazardous to Health) Regulations 2000 (USECHH Regulations),Chemical Health Risk Assessment (CHRA), Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease (NADOPOD), Factory and Machinery Act 1967, Notification, Certificate of Fitness and Inspection – Factory, Unfired Pressure Vessel, Safety, Health and Welfare, Noise Exposure - Noise Risk Assessment and Monitoring Mineral Dust – CHRA" (P4)

4.1.6 Theme 2: Factors that make up safety culture in mining industry

The respondents agreed that the identification of key factors of safety culture is useful in preventing major accidents or disasters in the mining industry. This theme generated three sub-themes:

(i) Management commitment and characteristics

Six respondents noted that the management commitment is crucial to fostering a good safety culture.

"Management commitment is very important to construct safety culture" (P1)

"Company must ensure (P2):

- *Commitment and priority by top management on safety;*
- *Safety incentives;*
- *Proper communication, e.g., Safety Officer, Management meeting;*
- *Transparency and investment in safety equipment;*
- *Enforce standard operating procedure (SOP) or follow standards;*
- *Staff attitude and behaviour; and*
- *Proactive and empowered to make the right decisions*

"Management commitment such as providing personal protective equipment (PPE), training, safety budget." (P3)

> *"Employer commitment and leadership, workers awareness of the importance of safety and involvement, has open and honest communication, has Monitoring, assessment, reporting, inspection, auditing, implementation and enforcement, Responsibility (Safety Health Officer, Safety Health Committee, Emergency Response Team, Department of Occupational, Safety and Health (DOSH), Firefighter, Social Security Organisation (SOCSO) Police, Natural Resources and Environment Board Sarawak (NREB), Mineral Geoscience and Department), finding the root cause of an incident, has a logical reasoning and knowledge in safety."* (P4)

In addition, the management commitment will reflect the leadership of the top management itself. The main characteristics of a leader or top management are:

> *"Understand the importance of safety at workplace."* (P1)

> *"Know the direction of company especially in managing safety issue."* (P2)

> *"Competent and well experienced in mining activities and operation."* (P3)

> *"Understand why safety is important in an organisation to, have a proper amount of knowledge in safety, ability to navigate and give proper instruction, fair judgement and open to suggestion, inspiring and constructive, has a good in communication skills, show involvement and support from time to time."* (P4)

> *"(1) Equip themselves with knowledge related to occupational safety and health so that there is a higher awareness and understanding; (2) Understand, apply, practice, and cultivate an overall safety culture to all members of the team or organisation so it becomes a continuous work style; and (3) Conduct continuous learning and knowledge sharing to improve knowledge and skills in security management."* (P5)

> *"Well experienced and understanding the importance of safety at mine site."* (P6)

<u>(ii) Safety culture awareness</u>

The six respondents highlighted that safety culture awareness in the mining industry is very low for small- and medium-scale mining operations compared to large-scale operations.

"There is no safety culture awareness for small-scale mining operation due to financial constraint and their mentality that safety is not their priority. I can say that maybe 30% the awareness exists but their focus is the profit. However. for large-scale mining operations, it can be up to 70%." (P1)

"The level of safety culture awareness in mining organisations is still at a low level below 50%, especially among small and medium companies, such as in most mining areas in Pahang, Kelantan, and Perak." (P5)

"In International mining operations, the safety culture awareness is very high as the senior management may be fired by their HQ if found to be negligent in enforcing these safety procedures in the workplace. In large local organisations, safety culture and procedures are generally in place. In small mines, may be lacking or does not exist - mostly compliance (or part) instead of being proactive. May lack communication to ground level staff, no funds for training or SHE staff." (P2)

"There is a huge gap in terms of level of safety culture awareness between small and large-scale mining operation due to financial constraint." Small-scale mining operation is below 50%." (P6)

<u>(iii) Safety culture programme</u>

The respondents mentioned there is an effort from the government to foster safety culture in the mining industry nowadays, such as:

"In general, the Minerals and Geoscience Department Malaysia (JMG) has conducted a rating programme (audit) known as the Sustainability Rating of the Mining and Quarrying Industry. Regarding the rating, among the things evaluated are aspects of safety practices and culture in mines. The programme is conducted annually from 2019 until present." (P5)

However, the examples of safety programmes that can contribute to a safety culture in the mining industry also depend on the initiatives of the mine company itself, such as:

"Safety training, safety meeting." (P1)

"Meeting of Senior management, Staff need to go for annual health checks, all hospital and clinical expenses are paid by the organisation will result greater productivity of experienced staff and workers. In the case of contagious or infectious diseases (e.g., COVID-19, flu) contacted by any staff, they will be immediately quarantined and not allowed into workplace unless cleared by medical doctor to avoid spreading of the disease to other workers." (P2)

"Conducting safety briefing, toolbox meeting, safety training." (P3)

"Safety briefing on Covid-19 outbreak and control measures safety briefing coal transport, toolbox meeting, Return-to-Work programme by Social Security Organisation (SOCSO), Noise and hearing conservation programme, Personal Protective Equipment (PPE) awareness: hearing protection device and respirator mask, noise hazard, exposure and risk at workplace; PPE awareness and workshop training or audit operator caterpillar by caterpillar agent; basic first aid and CPR course; Hazard Identification, Risk Assessment and Risk Control (HIRARC), Environmental Impact Assessment (EIA)workshop, fire drill training." (P4)

"Safety training, reward and punishment system, safety meeting." (P6)

4.1.7 Theme 3: Adapting safety culture in the mining industry

The six respondents highly recommended the safety culture, asserting that it is a must in the mining industry. This theme has two main sub-themes, as discussed below:

<u>(i) Benefits of promoting a safety culture</u>

The main aim of safety culture is to prevent accidents or disasters. Six respondents mentioned the benefits of promoting a safety culture in mining industry:

"(1) Protect health and safety of all workers and staff including contractors and part timers, for immediate accidents and environmental pollution, and for long term exposure to dust or radiation, causing lung diseases or cancer, et cetera. (2) Ensure compliance to local safety and environmental laws, so authorities will not shut you down, and take legal action for environmental damage, accidents or loss of life." (P2)

"To avoid accident and prevent recurrence, motivation to do a good job and to grow professionally, increase in productivity, and reduce downtime." (P4)

"All businesses aim for maximum profitability and continue to remain competitive in the industry. Accidents in an organisation must be avoided as they cause losses and involve very high costs and have a negative impact on the overall cost of the project and the psychological impact of the employees. Thus, this clearly shows that the process of cultivating safety in employment is a strategic investment for the short term and long term that will provide lucrative returns directly and indirectly. Based on my previous study conducted to identify the difference in cost of accidents that occurs at work for two types of projects carried out, compared with the cost required to succeed in a safety programme, it is found that the cost required to reduce accident rates through the purchase of insurance and implementation of safety programmes are much lower i.e. four times the cost as a result of the accident. A safe working environment will give a positive image that the mining industry is one of the fields of employment that is the choice of professionals, skilled and unskilled. High labour demand will provide healthy competition and sustainability in the industry." (P5)

<u>(ii) Challenges in promoting safety culture</u>

The challenges to promote safety culture in mining industry are as follows:

"Enforcement must be done frequently by local authority." (P1).

This concern was raised by P1 due to a lack of staff or enforce officers to monitor and conduct enforcement, especially on a small mining scale. The small mining companies want fast profits and ignore the safety aspects. This was also agreed to by P6, which stated:

"Poor enforcement from local authority such as Mineral and Geoscience Department Malaysia (JMG)." (P6)

"(1) Mine company usually hires local communities with little care or knowledge of mining and safety laws involved; (2) Overzealous politicians wanting the local community to benefit so overriding or approving laws for mining without due procedures or relevant authorities

concerned, for instance, the Mineral and Geoscience Department Malaysia (JMG)." (P2)

"Change the mindset of mining players/practitioners. Safety is a long-term investment, not a burden to a mine company." (P3)

"Occupational hazard in mining sector may differ from other sectors, such as oil gas and construction industry in Malaysia, thus, it is less discussed, studies, and hence, have lesser reference material. For example, there has yet to be specific guidelines for safety and health in coal mining in Malaysia. Without proper guidelines, safety culture is built more upon reactive response towards safety rather than proactive approach. This allows for imbalance of safety responsibility in an organisation thus create slow progress to promote safety culture." (P4)

"(1) An organisation needs to give equal attention to safety issues in the workplace on par with other things such as productivity and profitability to ensure the sustainability of an organisation. Provisions specifically need to be listed on par with other operational requirements. The understanding, commitment, and availability of the company's management in balancing these two things is the main challenge to the effectiveness of efforts to achieve these goals. (2) Individual factors such as attitudes and behaviors are among the big challenges. Every member in the team/organisation from the management level to the executive level must carry out functions and responsibilities so that the end goal can be achieved. Integrated support at every level in the organisation is an important element in measuring the extent to which these safety culture practices succeed or fail" (P5).

4.1.8 Discussion

The main purpose of this preliminary study was to investigate the general view on safety culture awareness and practises in the mining industry in Malaysia by interviewing mining experts. To the best of the researchers' knowledge, this was the first qualitative study on this topic undertaken in Malaysia. The mining experts expressed their concern about safety culture awareness and practises, which are still low, especially for small-scale mining operations. A common statement from the mining experts was that the mine owner should take full responsibility for providing a safe working environment for their workers. The management commitment is important to drive a safety direction towards constructing a good safety culture at mine workplace. For example, Yorio et al. (2020) analysed 24,910 mines in the USA and revealed that 469 accidents and fatalities occurred due to weaknesses in organisational safety and management's commitment towards handling safety issues among mine workers. Zhang et al. (2020) revealed that the poor safety culture reflects the weaknesses of the management's commitment to handling safety issues. Moreover, good leadership and coordination ability in management are key elements to constructing a good safety culture (Düzgün & Leveson, 2018).

In addition, the main challenge for the mine owner or mine operator was that they did not understand how safety could be the best investment for their company. This results in owners experiencing some burden, leading them to the preferable option of cutting down the safety allocation or safety budget. Eagerness to obtain profit or a fast rate of return also contributes to the negligence of safety aspects at mine companies, especially for small-scale mining operations. Financial constraints were always their excuses. For example, they did not provide proper personal protective equipment (PPE), safety training, or a safety programme to their workers. Therefore, the establishment of a safety culture among mine workers becomes more difficult. Furthermore, these findings agree with similar studies conducted in the mining industry in China (Fu et al., 2020), Australia (Rubin et al., 2020), and Ghana (Stemn et al., 2020). Table 4.4 shows the comparison of challenges in the construction of a safety culture in the mining industry in Malaysia with previous literature.

Table 4.4 Summary on challenges of safety culture awareness and practices based on literature and opinion mining experts

Challenges	**Based on Literature**	**Based on experts' opinion**
1. The mindset of mine owner and mine workers	The readiness of mine owner and mine workers to accept the concept of safety culture and understand this is a way or strategy to reduce mine accidents (Fu et al. 2020; Rubin et al. 2020).	*"Change the mindset of mining players and practitioners" (P4)*

Table 4.4 Continued

Challenges	Based on Literature	Based on experts' opinion
2. Lack of safety culture knowledge	Poor safety knowledge could lead to mine accidents. This includes poor safety training given by mine company to their workers could hinder in developing a safety culture at mine site (Jiang et al. 2020).	*"Change the mindset of mining players and practitioners" (P4)*
3. Safety training	To make sure the mine workers understand safety culture concept, the mine owner should provide a good safety training to the workers (Zhang et al. 2019).	*Individual factors such as attitudes and behaviours are among the big challenges" (P5)*
4. Poor communication channel from top management	Lack of effective communication channel between top management and mine worker (Jiang et al. 2020)	*"Integrated support at every level in the organisation is an important element in measuring the extent to which these safety culture practices succeed or fail" (P5).* *Without proper guidelines, safety culture is built more upon reactive response towards safety rather than proactive approach. This allows for imbalance of safety responsibility in an organisation thus create slow progress to promote safety culture." (P4)*
5. Poor safety regulation	Poor enforcement on safety rules could hinder the implementation of safety culture at mine site. Poor supervision also contributes to poor safety rules (Miao et al. 2020; Stemn et al. 2020).	*"Poor enforcement from local authority such as Mineral and Geoscience Department Malaysia (JMG)." (P6)* *"Enforcement must be done frequently by local authority." (P1).*
6. Safety equipment	Insufficient personal safety equipment provided by management (Miao et al. 2020; Düzgün & Leveson, 2018).	*Safety is a long-term investment, not a burden to a mine company." (P3)*

Source: Fu et al. (2020), Rubin et al. (2020), Miao et al. (2020); Stemn et al. (2020), Düzgün & Leveson, 2018), Zhang et al. (2019), Jiang et al. (2020)

Furthermore, based on the six experts' opinions and sharing of experience in the preliminary study, the researcher was able to summarise the influencing factors to establish a safety culture in the mining industry, as shown in Figure 4.3 and make comparisons with the influencing factors obtained from the SLR study. These following factors were very useful and significant as main inputs for the Delphi I and Delphi II studies.

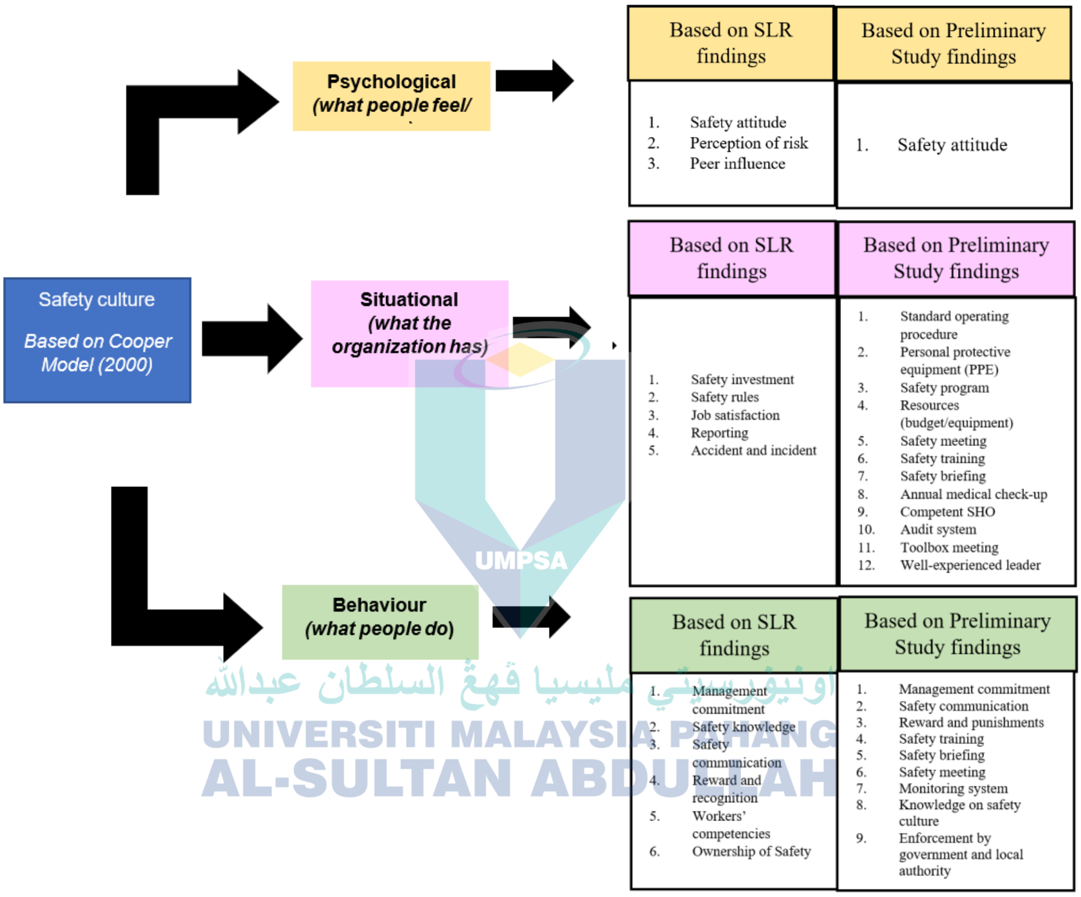


Figure 4.3 Factors to establish a safety culture in the mining industry in Malaysia based on the Preliminary Study

4.2 Results on Delphi I: Open-Ended Interview Questions

The findings from the preliminary study were useful for the Delphi study. Delphi Round 1, also known as Delphi I was conducted to investigate the influencing factors of safety culture in the mining industry. Delphi 1 involved open-ended interview sessions, and it was conducted from March 2021 until May 2021 with the participation of 21 panel experts, known as Delphi Experts. The Delphi study was aimed at covering the following objectives;

1) To investigate the influencing factors of psychological dimensions on the safety culture prevailing in the mining industry in Malaysia.

2) To investigate the influencing factors of situational dimensions on the safety culture prevailing in the mining industry in Malaysia.

3) To investigate the influencing factors of behavioural dimensions on the safety culture prevailing in the mining industry in Malaysia.

4.2.1 Selection of the Delphi Experts for Delphi I

The examples of consent forms for the Delphi I study, and initial invitations sent out by email to potential Delphi I participants are appended to Appendices E and F, respectively. Thirty (30) invitations were sent out based on the set criteria as shown in Table 3.8 previously. Out of 30 invitees, 21 agreed to participate in Delphi I study. The selection of experts in the Delphi process was important for this study. Experts were asked to send their curriculum vitae in order to confirm their areas of expertise and to ascertain whether they meet the qualifying criteria. The panel experts, or known as Delphi I experts were briefed on the overview and the objectives of the study. All of them received an official appointment letter from the faculty and also a detailed description of the Delphi study as appended in Appendix G.

The number of Delphi I Experts was adequate based on recommendations and suggestions from previous scholars in literature. Ten (10) to fifteen (15) panellists as suggested by Delbecq, Van de Ven, and Gustafson (1975), could be sufficient if the background of the panellists is homogenous, which was achieved in the current study. Rowe and Wright (2011) indicated that the size of a Delphi panel ranges from three (3) to eighty (80) in peer reviewed studies. Okoli and Pawlowski (2004) and Skulmoski, Krahn, and Hartman (2007) also indicated a panel size of about ten (10) to eighteen (18) members, while Hallowell and Gambatese (2010) suggested that since most studies incorporate between eight (8) and sixteen (16) panellists, a minimum of eight (8) is suggested. Hallowell and Gambatese (2010) further argued that the size of a panel should be dictated by the study characteristics, the number of available experts, the desired geographical representation, and the capacity of the facilitator.

Therefore, the 21 Delphi I experts involved in this study were considered adequate based on the fact that the Delphi method does not depend on statistical power, but rather on group dynamics for arriving at a consensus amongst experts. The Delphi I experts who agreed to participate in this Delphi study understood the process flow of method and volunteered, which is both time-consuming and difficult. The selection of panel experts, or known as Delphi I experts for the study was categorised into eleven (11), as shown in Table 4.5.

Table 4.5 Categories of Delphi I Experts and their locality

No.	Category	Position	Locality	Number of Expert
1.	Gold mine 1 representative	Senior Operating Mining Manager	Kelantan	1
2.	Gold mine 2 representative	Senior Chief Geologist/Mining Manager	Sabah	1
3.	Gold mine 3 representatives	Vice President Business Development (Mining)	Pahang	2
4.	Gold mine 4 representative	Safety Manager	Pahang	1
5.	Coal mine representative	Mining Manager	Sarawak	1
6.	Tin Mine 1	Safety Officer	Perak	1
7.	Tin Mine 2	Mine Owner	Pahang	1
8.	Mining consultants	Mining Consultants	Perak	3
9.	Government Agencies (JMG)	Director	Pahang	2
10.	Safety and Health Officers	HSE Manager and SHO EHS Superintendent	Pahang Selangor	2 1
11.	Academicians	Professor Assoc. Prof. Senior Lecturer	Sabah and Penang Kuala Lumpur Penang	2 2 1

The Delphi I experts consist of mine owners, mining consultants, top management of mining companies, academicians, government sectors, and safety and health officers that contributed to the construction of a safety culture in the mining industry. The selected participants represented a wide variety of backgrounds to guarantee a wide base of knowledge, as recommended by Rowe and Wright (2005). The background of Delphi I experts and their expertise are shown in Tables 4.6 and 4.7, respectively. The curriculum vitae for all the experts involved in the mining industry and related fields were available in supporting documents.

Table 4.6 Background of Delphi I Experts

Code name	Age (year)	Gender	Years of Experience	Highest Education	Current Position	Previous position
R1	54	Male	25	Diploma degree	Senior Operating Mining Manager	Senior Operating Mining Manager
R2	46	Male	24	Bachelor degree	HSE Manager	Safety Officer
R3	65	Male	39	PhD degree	Mining Consultant	Mining Engineer
R4	40	Male	15	PhD degree	Associate Professor	Lecturer
R5	47	Male	22	Bachelor degree	Director of government agency	Engineer
R6	48	Male	22	Bachelor degree	EHS Superintendent	SHO
R7	50	Male	30	PhD degree	Professor	Mining engineer
R8	49	Male	25	PhD degree	Senior Lecturer	Senior Geologist
R9	40	Male	10	Diploma degree	Safety and Health Officer	SHO
R10	48	Male	25	Bachelor degree	Safety Manager	SHO
R11	39	Male	14	Master degree	Mining Manager	Mining Engineer
R12	42	Male	22	Master degree	SHO	SHO
R13	50	Male	17	PhD degree	Professor	Lecturer
R14	39	Male	16	PhD degree	Senior Lecturer	Lecturer
R15	50	Male	30	Bachelor degree	Vice President Business Development (Mining)	Senior Geologist
R16	65	Male	36	PhD degree	Mining Consultant	Mining Engineer

Table 4.6 Continued

Code name	Age (year)	Gender	Years of Experience	Highest Education	Current Position	Previous position
R17	63	Male	36	Bachelor degree	Mining Consultant	Mining Engineer
R18	60	Male	25	Bachelor degree	Mine Owner	Lawyer (in mining)
R19	42	Male	20	Bachelor degree	SHO	SHO
R20	37	Male	12	Master degree	Mine Inspector	Mine Inspector
R21	50	Male	26	Bachelor degree	Senior Chief Geologist	Mining Manager

Table 4.7 The Delphi I expertise

Category	Code name	Subject Matter Expert					
		Mining operation	Mineral development	Mineral R&D	Organisational behaviour	Mine Safety	OSH (general)
Gold mine 1 representative (Kelantan)	R1	✓	✓	✓	✓	✓	✓
Gold mine 2 representative (Sabah)	R21	✓	✓	✓	✓	✓	✓
Gold mine 3 representatives (Pahang)	R15	✓	✓	✓	✓	✓	✓
	R2	✓	✓	✓	✓	✓	✓
Gold mine 4 representative (Pahang)	R9	✓	✓	✓		✓	✓
Coal mine (Sarawak)	R11	✓	✓	✓	✓	✓	✓
Tin Mine 1 (Perak)	R10	✓	✓	✓	✓	✓	✓
Tin Mine 2 (Pahang)	R18	✓	✓	✓	✓	✓	✓
Mining consultants	R3	✓	✓	✓	✓	✓	✓
	R16	✓	✓	✓	✓	✓	✓
	R17	✓	✓	✓	✓	✓	✓
Government Agencies	R5	✓	✓	✓	✓	✓	✓
	R20	✓	✓		✓	✓	✓
Safety and Health Officers	R6		✓		✓		✓
	R12		✓		✓		✓
	R19		✓		✓		✓
Academicians	R4		✓		✓		✓
	R7	✓	✓	✓	✓	✓	✓
	R8	✓	✓	✓	✓		✓
	R13	✓	✓	✓	✓		✓
	R14		✓		✓		✓

4.2.2 Thematic Analysis on Delphi I

The open-ended online interviews were successfully done with the involvement of 21 Delphi I experts with their vast experience related to safety culture and the mining industry, as shown in Tables 4.5 to 4.6, respectively. In order to identify themes related to influencing factors in safety cultures, a thematic analysis was carried out. The main issues, similarities, and differences highlighted and portrayed in the 33 articles obtained from the SLR study were identified and categorised. To construct themes in the Delphi I study, six steps were followed in the thematic analysis and were suitable for the qualitative analysis, as proposed by Nowell et al. (2017). The steps include:

1) Familiarisation with the data (understanding and analysing the responses from 21 Delphi I Experts based on an open-ended interview),
2) Generating the initial code (identify the similarities and differences based on the feedback from 21 Delphi I experts based on safety culture in mining industry),
3) Creation of themes (create or identify suitable themes to construct based on the identified similarities and differences)
4) Reviewing themes (ensuring the proposed themes and subthemes are within the main context of influencing factors of safety culture in the mining industry in Malaysia)
5) Defining and naming themes (three main themes, which are dimensions and 24 sub-themes or factors were created in this study)
6) Producing a report (in this case, it refers to the proposed safety culture framework in the thesis)

The Participant Information Sheet for Delphi I and open-ended questions used in the study were appended in Appendices H and I, respectively. Table 4.8 shows the mapping table on thematic analysis based on the open-ended interview with 21 Delphi I Experts. Three main dimensions or themes were created; Psychological, Organisational, and Behavioural dimensions, with 24 sub-themes or influencing factors of safety culture.

According to Table 4.8, there are 24 influencing factors obtained from 21 Delphi experts' opinions that have similarities and are in line with the opinions of six mining experts in the preliminary study (as discussed in Figure 4.3). Safety attitude, management commitment, and safety training were among the factors highlighted by experts during the preliminary and Delphi I study. Similar influencing factors aired by the mining experts for both studies showed that they have the same thoughts, opinions, and experiences on the critical influencing factors to construct a safety culture in the mining industry in Malaysia.

According to SLR, as shown in Section 2.3.7 (Figure 2.12), 29% of the situational dimension (5 factors), 24% of the psychological dimension (4 factors), and 47% of the behavioural dimension (8 factors) had the largest influence on the development of safety culture in the mining industry. However, using thematic analysis in accordance with the preliminary study and Delphi I, the following results were obtained: behavioural dimension: 37.5% (9 factors), situational dimension: 41.7% (10 factors), and psychological dimension: 20.83% (5 factors). These results demonstrated that the situational dimension had the largest influence on the development of safety culture and the highest number of components identified during the study.

Moreover, based on Table 4.8, the frequency refers to the repetitive word usage or idea that was highlighted by all Delphi I Experts during the interview session. Moreover, the definition for each factor was created based on the researcher's understanding of the opinions and feedback from experts, as shown in Table 4.8. These definitions also became guidelines for the AHP experts later on to prioritise the factors discussed in Section 4.4. These factors were further refined and validated in a Focus Group Discussion (FGD) and at a volunteered mining company X as a case stu

Table 4.8 Mapping table on thematic analysis for Delphi Round 1 (interview)

Dimensions (Themes)	Factors (subtheme)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	Frequency	Percentage (%)
Psychological	1. Management concern/ care on workers	/	/	/			/		/	/													6	28.6
	2.. Safety attitude	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/		/	/		/	18	85.7
	3. Job satisfaction											/											1	4.8
	4. Health of worker			/			/		/	/									/			/	6	28.6
	5. Peer influence										/	/											2	9.5
Situational	1. Safety policy	/	/		/					/	/	/	/		/		/		/	/		/	12	57.1
	2. Safety audit									/	/										/		3	14.3
	3. Safety rules	/	/	/		/		/	/	/		/		/	/				/	/	/		13	61.9
	4. Competent SHO/	/	/					/	/	/	/	/	/	/					/	/			11	52.4
	5. Safety education	/	/	/	/	/	/	/	/	/	/	/		/	/	/	/			/		/	17	81.0
	6. Safety programme		/			/	/	/	/	/		/				/			/	/			10	47.6
	7. Safety planning						/				/			/		/						/	5	23.8
	8. Medical surveillance	/	/				/		/	/									/			/	7	33.3
	9.Safety competency	/			/	/		/	/	/	/	/	/		/	/	/	/	/		/	/	16	76.2
	10. Safety signage	/	/	/	/	/	/		/	/			/	/			/				/	/	13	61.9
Behavioural	1. Management commitment and action	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	21	100
	2. Safety communication	/	/		/	/	/		/	/	/	/	/	/	/		/	/		/			15	71.4
	3. Leadership	/	/	/				/		/	/	/			/				/	/			10	47.6
	4. Safety training	/	/	/	/	/	/	/	/	/	/	/			/	/	/		/	/		/	17	81.0
	5. Safety awareness		/	/		/			/				/	/				/					7	33.3
	6. Safety reporting					/				/				/						/			4	19.0
	7. Safety promotion					/							/	/		/		/		/			5	23.8
	8.Enforcement on wearing PPE	/	/	/	/	/	/	/	/	/	/	/			/	/	/		/	/		/	17	81.0
	9.Reward and punishment	/	/	/	/	/	/		/	/	/	/		/	/	/		/	/	/			16	76.2

Table 4.8 Continued

Psychological dimension

1. Management care on workers: Refers to management's interest with workers' psychological conditions as they relate to their work environment and performance.
2. Safety Attitude: Refers to mine workers' psychological attitudes regarding workplace safety culture, procedures, and accident prevention.
3. Job satisfaction: Refers to a worker's satisfaction with the task he or she has been assigned without undermining the employer's efforts.
4. Health of Worker: Refers to a worker's physical and mental ability to do the task at hand
5. Peer influence: Refers to co-workers or colleagues who have a significant impact (good or bad) on the development of a workplace safety culture.

Situational dimension

1. Safety policy: Refers to the mining companies stated OH&S policy and OH&S objectives, which include compliance with OSH legal requirements and other government-imposed requirements.
2. Safety Audit: Refers to the auditor's internal and external audits, and ensure that all records are appropriately documented for future reference.
3. Safety rule: Refers to all of the mining company's developed standard operating procedures, guidelines, rules, regulations, and safety practices, which must be followed by all mine personnel and do not conflict with local authorities' and government's requirements.
4. Competent SHO: SHO who is well-trained and experienced in mining operations and activities is referred to as a competent SHO.
5. Safety education: Refers to any training offered by management to improve employees' safety skills and knowledge.
6. Safety programme: Refers to current and completed programmes, events, and activities such as safety awareness week, safety first, and others.
7. Safety planning: Refers to all short and long-term plans, as well as ongoing safety planning offered to employees by senior management. For future reference, everything forthcoming and completed planning must be carefully documented.
8. Medical surveillance: Top management assigns an Occupational Health Doctor to evaluate employee health and safety to ensure that employees are physically and psychologically capable of doing their duties.
9. Safety competency: Refers to employees' prior safety knowledge and work experience, as well as any ongoing safety training or education they get to improve their professional abilities and competences.
10. Safety signage: Refers to any chemical signage, working station signage, mining site signage, or safety promotion signage is used to keep personnel informed of impending dangers.

Behavioural dimension

1. Management action and responsibility: Refer to top management's commitment to ensuring that all employees follow the company's safety policies and rules.
2. Safety communication: Refer to management's communication channels, such as email, memos, safety briefings, bulletin boards, reporting systems, and others, to guarantee dual communication between employees and employers.
3. Leadership: Refer to a well-trained and experienced SHO, supervisor who is capable of effectively leading and supervising personnel.
4. Safety training: Refers to management's commitment to offer staff with sufficient training and competence courses.
5. Safety awareness: Refers to employee knowledge of the significance of safety and the culture of safety at work, as well as comprehension of safety policies. Standard Operating Procedures (SOPs), standards, and regulations
6. Safety reporting: To report misbehaviour or unethical concerns involving workers or supervisors, use the management-provided method, which may be used either offline (manually) or online.
7. Safety promotion: Any promotion, including activities and programmes created by management to instil a safety culture at work, such as safety week, safety film, safety signs, safety talk, and safety seminar and others
8. Enforcement on safety rules: Refer to the established SOP, regulations, and standards, which must be adhered to by all levels of personnel.
9. Reward and punishment: Refer to bonuses to reward excellent employees, or any misbehaviour and unethical behaviour by employees must be penalized.

4.2.3 Discussion on Theme 1: Psychological Dimension

Objective 1 of this study is to investigate the psychological dimension of safety culture. Based on the open-ended interviews conducted for Delphi I, the theme of the Psychological Dimension with five main influencing factors on safety culture was generated based on the feedback from Delphi I experts. The percentages were calculated based on the frequency of the word used or highlighted by all Delphi I experts, with a total of 21 experts during the interview session, as shown in Table 4.8. All these were analysed using the thematic analysis as discussed in Section 4.2.2. The five factors were created, which are: (1) management care for workers, (2) safety attitude, (3) job satisfaction, (4) worker's health, and (5) peer influence. Based on Delphi I, the most influencing factor of the psychological dimension was safety attitude with 85.7% followed by management concern (28.6%), health of the worker (28.6%), peer influence (9.5%), and job satisfaction (4.8%), as shown in Figure 4.4.

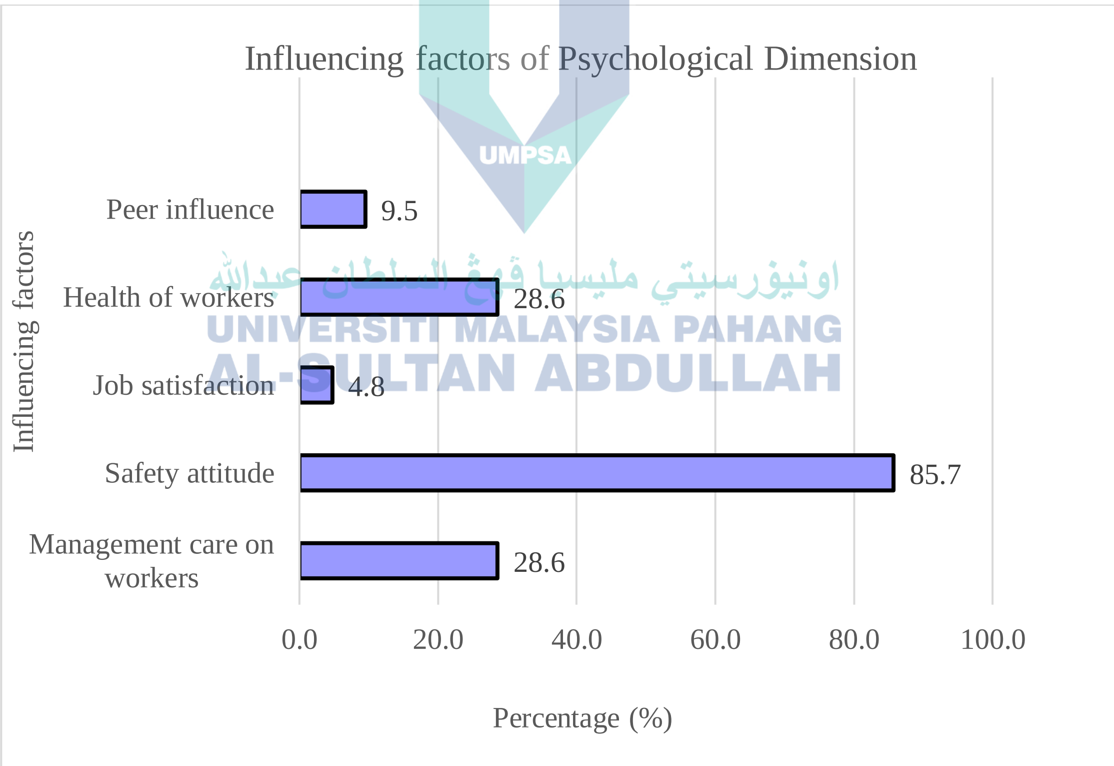


Figure 4.4 Influencing Factors for Psychological Dimension based on Delphi I (21 experts)

i) Factor 1: Safety Attitude

Most of the respondents agreed that the safety attitude of mine workers is important to achieving a good safety culture. Based on Figure 4.4, safety attitude indicated the highest influencing factor for creating a safety culture, with 85.7% of the respondents agreeing on it. According to the Senior Operating Manager with 25 years of working experience in the mining industry, he stated;

> *"The ego of workers and bad safety attitude which are reluctant to follow the rules are great problem to company. This made more difficult if they had low educational background such as qualification from secondary school only. It makes difficult to train them because they have their own bad attitude"*

This was supported by the Director of a mine company (R18), who stated;

> *"The safety attitude among workers is challenging to handle especially most of my workers are from Indonesia, Myanmar, Bangladesh. The bring along their safety attitude from their origin countries."*

ii) Factor 2: Management concern on workers

This factor was generated based on the thematic analysis, with 28.6% of the respondents agreeing that management concern for workers is important. The great concern of the employer towards his worker could create a good relationship or bond between them and reduce the problem at the workplace. This includes the language barrier among the workers. This concern was raised by the Safety and Health Officer (R6), who stated;

> *"To create a good safety culture, the management must become a role model for the worker such as concern on their welfare. If any accidents occurred on them, the company will take a full responsibility about it. Moreover, the language barrier can hinder the formation of safety culture if there a foreign worker that work at mine site which cannot understand the information disseminate to them."*

iii) Factor 3: Health of workers

Workers' health is sometimes not a big concern to mine owners. However, poor workers' health can interrupt mining operations, such as due to a shortage of the workers or a delay in performing the given task. Based on Figure 4.2, 28.6% of the mining experts agreed that workers' health is an important factor in creating a good safety culture. This concern was raised by the Safety Health Officer (R6). He said,

> *"Psychological problem of worker such as stress, depression may create a problem to company and directly contribute to poor safety culture. Workers' health seems may not important but actually the workers are the company's asset. The employers should provide a medical surveillance or annual health screening to all their workers to ensure they are fit to perform their daily task."*

vi) Factor 4: Peer influence

Based on Figure 4.4, peer influence was in fourth place, with 9.5% agreed that peer influence is significant in safety culture. This was supported by Mine Manager (R11, who stated;

> *"Despite of having bad safety attitude, peer influence also plays a great role to create a good safety culture. But in my company, the peer influence didn't give much influence because the workers are daily worker. Their salary is daily basis so they need to show the good attitude."*

v) Factor 5: Job satisfaction

Job satisfaction was the least influencing factor contributing to creating a safety culture, with 4.8% of the respondents stating it. According to the Mine Manager (R11);

> *"The performance of workers also depends on their satisfaction while working at mine site. The employer needs to ensure they feel safe and their well welfare are well taken care."*

4.2.4 Discussion on Theme 2: Situational Dimension

Objective 2 of the study was to investigate the influencing factor of situational dimension in safety culture. The Theme 2: Organisational dimension was created with the ten significant influencing factors, or sub-themes, by using thematic analysis. The percentage was calculated based on the frequency of the word used or highlighted by all Delphi I Experts during the interview session, as shown in Table 4.7. Based on Figure 4.5, safety education was the most influencing factor in the situational dimension with 81.0%, followed by previous education and working experience (76.2%). The least influencing factor based on Delphi I was the safety audit, with 14.3%.

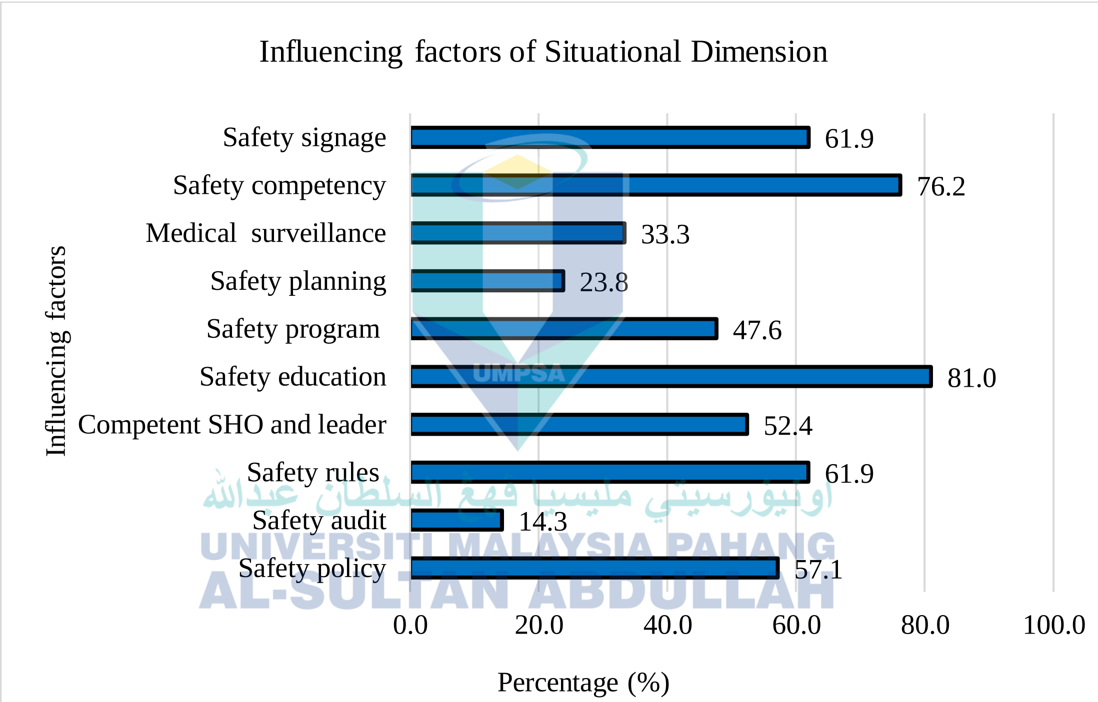


Figure 4.5 Influencing Factors of Situational Dimension based on Delphi I (21 experts)

Factor 1: Safety education

The highest factor for inculcating safety culture in mining organisations is safety training and education (81%). Top management must provide safety training and competency courses to all workers. It will improve and enhance knowledge, safety awareness, and competency and skills among workers. Moreover, most mining experts also agreed that the safety training is a good solution to increase productivity, avoid injuries or near misses, and reduce mining accidents. All this would be helpful to construct a good working ethic among workers and a safety culture that can be achieved. One of the mining consultants (R3), with 39 years of working experience, said;

> *"Safety training is a key factor to establish safety culture. The top management must provide an adequate safety training to enhance worker's skill and professional competency."*

Factor 2: Safety Competency

Previous educational backgrounds or working experiences are part of the workers' safety competency to contribute to a safety culture. 76.2% agreed that previous education background and working experience of mine workers can give them self-awareness and educate themselves on the importance of safety culture while performing their job, as shown in Figure 4.5. The existing culture of safety that developed from their previous working experience or education could benefit their existing employer or also give them an advantage once they change to another company. However, there was a different opinion from a mining expert, in which safety culture is not dependent on previous working experience or education. It must be continuously trained by the employer, as pointed out by the Mining Consultant (R3). He mentioned;

> *"I believe the safety culture of employees can be trained by employer. The key important here is employer must provide an adequate safety training to the employees".*

Top management must provide all safety competencies to their employees. This is important to train or to retrain the employees to increase their skills and knowledge in a certain area according to their job scope.

Factor 3: Safety rules

Safety rules are a reflection or subset of safety policy. A mining company's clear safety policy will produce or generate good safety rules that are valuable to the company and will ensure they are followed by all levels of mine workers. Based on Figure 4.5, safety rules were in third place, with 61.9% agreed they were significant in safety culture.

For example, the standard operating procedure (SOP) produced by the management must have the involvement and points of view of their employees to ensure the mining operation can run smoothly and reduce unnecessary incidents and accidents.

A Safety Health Officer (R9) agreed that safety rules are mandatory for all workers. He said;

> *The issues related to safety rules must be highlighted during tool box meeting, safety briefing, and safety meeting. All the workers must be informed on any accidents or injuries occurred at working area during the meeting. The workers must be reminded on safety rules by having a safety notice board and so on."*

Factor 4: Safety signage

The fourth place was safety signage, with 61.9% agreed it was significant in the formation of a safety culture in the mining industry. Safety signage is important to construct a safety culture in mining organisations. This includes a safety signage at the mine sites, administration offices, processing areas, and chemical storage areas. The safety signage can remind the workers to abide by the rules while performing the job, make it part of their work ethics, and continually become part of their working culture. However, some of the mining experts said that even though the management provides safety signage, there are problems among miners who prefer to take a shortcut method while performing the job, which could lead to near misses, injuries, or accidents (Jiang et al., 2020). The safety signage is important, as mentioned by the mining experts (R4, R5, R8, R12, R13, and R21) who stressed on the importance of having a good safety signage, such as chemical use and hazards signage, at the mining site to ensure the mine workers are alert to the safety practises while performing their tasks.

Factor 5: Safety policy

According to the participants, the factor that contributes most to situational safety culture is safety policy, with 57.1%, as shown in Figure 4.5. Management must establish a clear Occupational Health and Safety (OH&S) policy and OH&S objectives for their respective mining company in the first place and must ensure compliance with OSH legal requirements and other requirements set up by the government. Twelve (12) Delphi I

Experts agreed that a clear safety policy would help mining operations can run smoothly because all levels of workers or management have the same direction to ensure safety is the main priority. A Mining Consultant with 36 years of working experience believes (R7);

> *"Making safety as part of workers' key performance indicator or individual annual assessment and can motivate the workers to work in a safe manner and inculcate a good safety culture at mining company. It must be stated in safety policy of the mining company."*

Moreover, a HSE Manager with 25 years of experience said (R4):

> *"The top management has a clear policy and can be implemented in the organisation. Must have safety system such as middle management and bottom management to ensure the safety policy will be followed by all workers. All this required to build safety culture in mining company."*

Factor 6: Competent SHO

The next contributing factor to safety culture is the appointment of competent Mine Managers and Safety and Health Officers (SHO) in the mining industry who really understand the nature of the work of mining operations. Based on Figure 4.5, 52.4% of the mining experts agreed it was significant. According to the Senior Operating Mining Manager (R1), with 20 years of working experience in the mining industry, he mentioned;

> *"There is a problem in mining industry where the Mine Manager himself does not stress on the importance of safety aspect in mining operation especially for small scale mine operation. Mining industry doesn't require to appoint SHO under Occupational Safety Health Act (OSHA 1994) and Factory Machinery Act (FMA). Therefore, we can see the small-scale mine companies neglect the safety aspect and have poor safety culture. It worsens because nobody responsible on safety issue related at mine site. In contrast, for large scale mining operation (>100 workers), the have proper safety policy, hired competent Mine Manager and SHO to ensure the safety is their main concern. This is because they have financial stability compare to small scale mine operation."*

Factor 7: Safety Programme

Safety programme is one of the most important factors of safety culture, as stated by the experts, with 47.6% agreed on it. A safety programme can consist of such things as a safety briefing session, a toolbox meeting, a safety week, or a safety talk, which aim to raise awareness among all mine workers. According to the Safety Manager (R10), with 25 years of mining experience, he stated;

> *"A good Safety Officer is the one that can plan safety programme and propose to the company and make sure it can be executed successful with the participation by all the mine workers."*

Factor 8: Medical surveillance

The health issues of mine workers were pointed out by some of the mining experts. Some mine owners do not acknowledge their workers as their main asset of the company. It was ranked eighth place with 33.3% of the mining experts agreed it was significant to create a safety culture in the mining industry. For example, in a small-scale mine operation, the workers' health is not their priority, and to make matters worse, the management does not provide an annual health check-up for the workers. According to the Safety Health Officer *(R4);*

> *"It is responsible of top management to ensure the workers work at a healthy condition and all the health issue must be reported to the management. The management also must ensure their workers to have health screening or annual check-up. It believes a healthy worker will increase the productivity of company and prevent from mine accidents or unnecessary incidents."*

This was agreed upon by most of the mining experts: to construct a good safety culture in mining organisations, health issues need to be highlighted. The top management must provide good medical surveillance, such as an annual medical check-up for their mine workers. A healthy worker will support and follow all the safety rules, perform their work in a fit condition, and be more productive. Moreover, it will also prevent any near misses, injuries, or occupational accidents at the workplace. According to the Vice President Business Development in Mining (R6), with more than 20 years of working experience, he stated;

> *"One of element to construct a safety culture is by having a healthy worker. A healthy worker is our main priority. We, as top management provides Occupational Health Doctor to handle health issues among workers including mental health issue. All mine workers including management are compulsory to do annual medical check-up and health screening."*

Factor 9: Safety planning

Safety planning refers to the brainstorming or ideas from the top management for short-term and long-term events or any activities related to safety that are beneficial to the company and workers. 23.8% of the mining experts said it was significant to create a safety culture. A successful OH&S policy can be measured by good execution of safety planning and employee participation at the mining company. Examples of safety planning and communication by the company include the safety week, safety induction course, safety training, safety promotion, safety talk, daily or weekly safety meetings, annual medical check-ups, and so on. Safety planning is a subset of OH&S policy. If the mining company has a clear policy, all the safety can be planned ahead, including taking into account the budget or allocation that is required to make all the safety planning successfully. If all this planning becomes part of the organisation's culture, the safety culture will exist in the respective company.

A Mine Inspector (R10) highlighted a huge gap between safety planning and small-scale, as well as large-scale mine operations in Malaysia.

> *"We have conducted Occupational Safety and Health Work Assessment (OSHWA) for various industries including mining, most of mining companies in Pahang get grade D (35-45%) and grade E (below 35%) especially for small scale mine operation. For large-scale mine operation is can be up to 80%. I believe other mining company at various states in Malaysia also have similar results. One of main constraint for small-scale was they do not have enough financial resources compared to large."*

Factor 10: Safety Audit

One of the factors that the experts pointed out was the safety audit. Only a few of the mining experts mentioned that the safety audit contributes to the safety culture in organisations, with only 14.3% of the Delphi I experts mentioning it. Most of the mining operations in Malaysia are currently small-scale operations; therefore, the potential to ignore the safety audit aspect is high. Small mining companies are eager to be profit-oriented and have a tendency to ignore on safety aspects, especially safety audits. Moreover, a lack of monitoring or safety culture audit by the government agency overseeing mining operation is also one of the influencing factors in constructing safety culture. This is proven and in line with the statement of the Mine Inspector with 12 years working experience (R10);

> *"In DOSH, we have Occupational Safety Health Work Assessment (OSHWA) to assess and evaluate the safety issues at mine site. One of criteria is the documentation audit and ergonomic that related to safety culture. It covers the responsibility of company to follow all the checklist provided by DOSH and contribute to formation of safety culture. Regarding to OSHWA, most of mining companies in Pahang get grade D (35-45%) and grade E (below 35%). In Malaysia also have similar results. Moreover, Sustainable Development Indicator (SDI) to inculcate the mining company to have self-regulating and assess or evaluate their safety performance. This was started in 2019."*

4.2.5 Analysis on Theme 3: Behavioural Dimension

The third objective of the study was to investigate the influencing factors of the behavioural dimension of safety culture. Based on the feedback from the experts, nine factors were highlighted, as shown in Figure 4.6. Based on Figure 4.6, management action was the most influencing factor of the situational dimension with 100%, followed by enforcement of safety rules (81%), and safety training (81%). The least influencing factor based on Delphi I was safety reporting, with 19%.

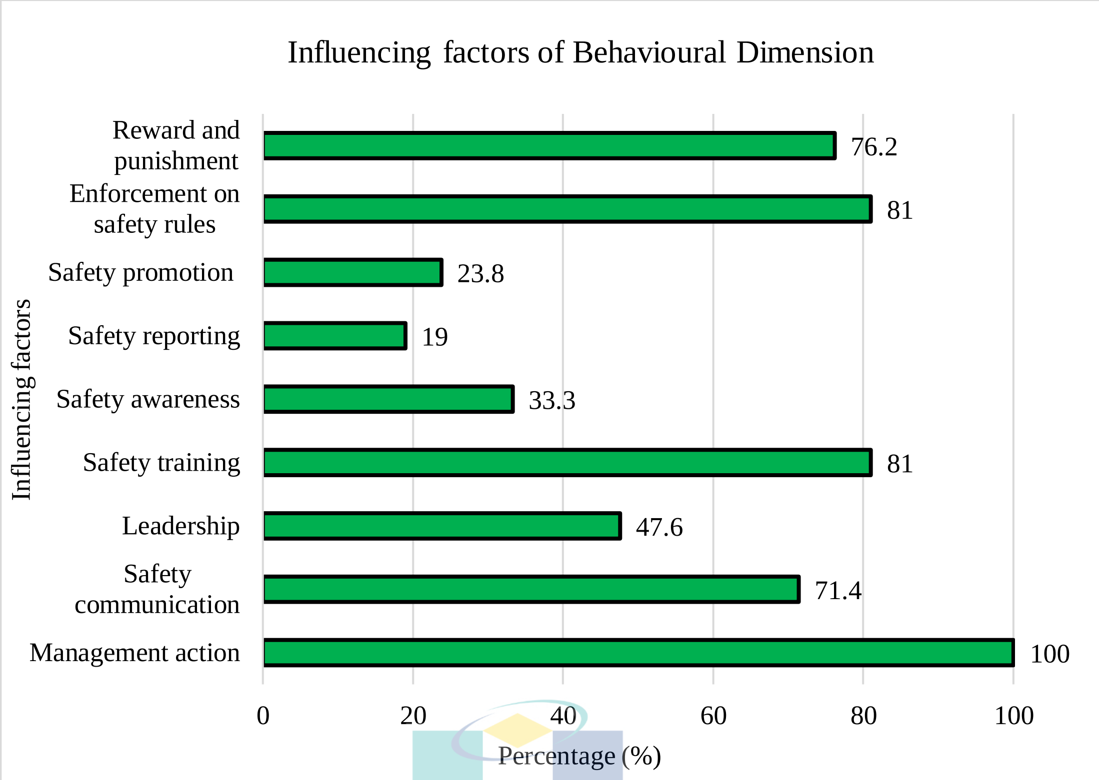


Figure 4.6 Influencing Factors of Behavioural Dimension based on Delphi I (21 experts)

Factor 1: Management action and responsibility

Most of the experts stated that the main factor in the behavioural dimension was the responsibility of the mining company itself to provide a good working environment to the workers. This factor recorded the highest agreement, with 100% agreed on it. Even though the mining operation deals with a harsh and inconvenient environment, the safety aspect must be the main priority of the mine owner. According to the Senior Operating Manager (R1) with 25 years of working experience in mining industry, he stated;

> *"Mining manager should take responsibility for entire safety aspect at mine site. Mining company should invest in safety and not only focus on profit."*

This was agreed upon by the HSE Manager (R2), who stated that the responsibility of the mining owners and top management must include;

> *"Top management must provide a good safety policy, safety briefing, signage such as for chemical used, safety*

signage, safety training and annual medical check-up to employees, assign a competent supervision, and also provide reward and punishment system."

<u>Factor 2: Enforcement on safety rules.</u>

The second highest factor was enforcement of safety rules, with 81% of the experts expressed their opinion on the importance of this factor. Most of them mentioned that the mine company should have a clear safety policy, but the enforcement must be executed to make sure all the employees or mine workers abide by the rules. According to a former Senior Geologist with 20 years of experience in the mining industry who is currently working as a Senior Lecturer (R8), he stated;

> *"Mining company must assign safety officers to make sure the enforcement of safety rules exists and followed by all level of workers. This is also part of role of management commitment towards creating a good safety culture."*

<u>Factor 3: Safety training</u>

The third factor was safety training, with 81% agreed on the importance of safety training in creating a safety culture in the mining industry. Safety training is significant to increase the competency of workers, as well as educate them about the importance of safety while working or handling machinery, transportation, and many more. According to the Mining Consultant (R3), with 30 years of working experience in mining operations, he said;

> *"For me, the main factor to create safety culture was the mine owner should provide various intensive safety training to their workers. Management should allocate of have safety budget which must be include the safety training and competency courses in the company's budget. Safety must be trained with a good safety education and proper training."*

This was agreed by another Mining Consultant (R17). He mentioned;

> *"The safety culture for local or small mining companies compared to was low because they do not have enough money or budget such as for safety training, good PPE, and many more."*

Factor 4: Reward and punishments

The fourth factor was reward and punishment, with 76.2% agreed on it. To create a good safety culture, some of the experts mentioned that the mining company should have a good reward and punishment system. According to Professor (R13);

> *"Give reward and incentives to worker to motivate them to follow all the safety rules."*

This was also agreed by the Safety Manager (R12). He stated;

> *"My company provide bonus or reward to the workers that show a good safety practices and attitude. This will directly inculcate all the workers to follow the rules and exhibit a good safety culture at workplace."*

Factor 5: Safety communication

The fifth factor that is important is safety communication, with a result of 71.4%. The dissemination of safety information includes safety briefings, safety meetings, safety inductions, memos, safety signage, safety promotions, and many more. This is important to ensure all levels of workers are aware of safety at the workplace and any safety planning organised by top management. This factor was raised by many respondents, such as the Safety Manager (R10) and the Safety Health Officer (R19). According to R19,

"Management should provide a safety communication channel to disseminate the safety information. Safety is not the hidden cost. It is kind of investment to the company."

Factor 6: Leadership

The sixth factor was leadership, which included the leadership of supervisors and safety officers, and 47.6% of the mining experts agreed on it. The Safety Officers (R12 and R19) mentioned that;

> *"The management should appoint the well-experienced safety officer (SHO) that understand the nature of mining works." (R19)*

"Appoint a competent and well-experienced SHO." (R12)

This is important because a well-experienced safety officer can plan, strategise, execute, and monitor the safety activities and programme for the whole mine company with the cooperation of all levels of workers.

Factor 7: Safety awareness

One of the main factors in making sure the safety culture can be developed in the mining industry is that the mine workers themselves have safety awareness. Safety awareness is highly dependent on the effort of top management to organise safety programmes such as safety talks and safety weeks. Based on Figure 4.6, 33.3% agreed that safety awareness is important. Moreover, providing safety signage, toolbox meetings, and safety briefings can be done to ensure safety awareness exists.

According to the HSE Manager (R2), he mentioned;

> *"It is one of main job scope of Safety and Health Officer (SHO) to ensure the awareness on safety culture exists at mining company. The top management also must support all the programme organise or proposed by SHO."*

Factor 8: Safety promotion

The next factor is safety promotion, which resulted in 23.8%, which is really close to safety awareness. Safety promotion can be varying, such as organise safety weeks, promote wearing a good PPE, safety signage, safety corporate videos, brochures, posters, and safety talks. This is important so that all the information on safety culture can be disseminated and understood properly.

According to the Safety and Health Officer (R12), he mentioned;

> *"Promotion of safety (at mine site) in a creative way such as short video (on safety). The conventional method such as banner/poster may be not suitable anymore. Government also must do aggressive promotion on safety at workplace through social media and so on."*

Factor 9: Safety reporting

The final factor is safety reporting, with 19% agreed that it is one of the important factors in creating a safety culture in the mining industry. Safety reporting includes reporting the errors, accidents, and near misses that occur at the workplace. This is also important as a main reference in the future and to avoid repeating the same mistakes. Safety reporting, such as a safety culture assessment at the workplace, can be a guideline in the future to improve current safety practises and become physical documentation for the company. Moreover, safety reporting can also be a proof that the company follows all the rules and regulations enforced by local authorities. All the reports must be kept confidential for future reference.

According to the Director of JMG Pahang (R5), he mentioned;

> *"Safety reporting is important as a proof of misconduct on safety activities of practices by mine workers at mining site and if there is accidents occurred, it can be referred as well and also be part of lesson learnt from previous accident."*

4.2.6 Discussion on Delphi I

Delphi I was successfully completed by interviewing 21 Delphi I experts. Based on the mapping table and thematic analysis as shown in Table 4.8. Safety culture was built on three main foundations (Schein, 1989): (i) Psychological or people factor, (ii) Situational or working environment factor, and (iii) Behavioural factor. The Delphi I study successfully investigated the influencing factors on psychological, situational, and behavioural dimensions to construct a safety culture in the Malaysian mining industry.

For the psychological dimensions, five influencing factors were identified: Safety Attitude (85.7%), Management concern for workers (28.6%), Health of workers (28.6%), Job Satisfaction (4.8%), and Peer Influence (9.5%). Safety attitude contributes the most to the psychological dimension of safety culture. Most of the experts stated that to create a safety culture in the Malaysian mining industry, the attitude of workers towards safety must be changed first. The mine workers should be concerned about and prioritise safety while working, such as wearing Personal Protective Equipment (PPE), being responsible for reporting any incident or accident that occurs, following the rules and guidelines, and cooperating with the top management by participating in any safety programmes or activities organised by the company. Mutual understanding between workers and employers is important to develop a good safety culture at a company. According to Hu et al. (2011) and Wang et al. (2018), miners' safety attitudes focus on their psychological orientation towards safe culture, procedures, and accident prevention. For example, Rubin et al. (2020) conducted a survey on 233 miners and found that the main constraint of miners' ability to inculcate a safety culture was a lack of safety motivation, which led to a low safety attitude. Therefore, it is crucial for employers or top management to improve the safety attitude of their workers, such as through handling safety training or a safety programme.

For situational dimensions, ten influencing factors were identified, namely: safety education (81%), safety competency (76.2%), safety rules (61.9%), safety signage (61.9%), safety policy (57.1%), competent SHO (52.4%), safety programme (47.6%), Medical surveillance (33.3%), safety planning (23.8%), and safety audit (14.3%). This study revealed the ten factors needed to construct a safety culture in the mining industry by interviewing mining experts who have vast experience in the mining industry in Malaysia. Based on these findings, safety education is important to educate the mine workers and create a safety culture at the workplace (Jiang et al., 2020). It is the responsibility of the top management itself (mine owner or mine operator) to provide a safe working environment, ensure a culture of safety exists among the mine workers, and most importantly, ensure all related safety is in compliance with the government's needs. Moreover, safety competency also needs to be strengthened among mine workers to ensure they abide by the rules and understand well all the safety requirements at the mine site. Moreover, all mining experts agreed that the safety policy must be clear at the top management level. The mine owner or top management plays an important role in initiating a safety culture in their organisation with the support of their mine workers. The efforts of top management to make safety culture their main priority are important, such as having a good safety policy, safety training, and a safety programme. The management also must set a good example, which motivates the employees to participate in and support any activities that are organised.

Behavioural dimension with the nine factors was generated by using thematic analysis (Nowell et al., 2017), namely management action and responsibility (100%), enforcement of safety rules (81%), safety training (81%), reward and punishment (76.2%), safety communication (71.4%), leadership (47.6%), safety awareness (33.3%), safety promotion (23.8%), and safety reporting (19%). According to Cooper (2000), behavioural dimension refers to *what people do*, which is based on actions taken by management and workers to ensure a safety culture exists at the workplace. The effort of the mine owner or mine operator, as well as the involvement of workers are important to ensure a safety culture exists. For example, reporting on accidents, misconduct, or any breach of safety rules is important, as reported in coal mines in China (Rubin et al., 2020), Ghana (Stemn et al., 2020), and India (Dash et al., 2016), as well as gold mines in South Africa (Hussain et al., 2018).

One of the interesting findings in the Delphi I study was the current status of safety culture awareness and practises among mining organisations in Malaysia, as highlighted by the HSE Manager (R2). A huge gap in safety culture awareness between small-scale and large-scale mine operations is quite worrying, at 30% and up to 80%, respectively. Small-scale mine operations are eager to have a quick rate of return, which therefore drives them to neglect the safety aspects. However, in this case, the gap can be reduced if the mine owner of a small-scale mine operation is ready to change their mindset and understand that the safety issue is part of their investment. For example, if there is an accident, their production will face problems due to a lack of manpower or mineworkers. Therefore, they required a clear safety policy with good safety planning, and at least all the workers understood the importance of safety rules while handling any machinery and tried to avoid any injuries or near misses while working at the mine site.

In addition, the top management, whether for small- or large-scale mine operations, is also required to provide clear OH&S and safety rules because it will help the mine workers become more disciplined, and become a habit, and turn them into responsible mine workers. Large-scale mine operations have many advantages and can create a good safety culture in organisations easier, as required by the government, because they have strong financial resources and are able to provide and organise safety programmes for their employees. However, the lack of employee participation may also hinder the effectiveness of safety culture in mining organisations (Eskandari, Jafari, Mehrabi, and Pouyakian, 2017).

4.2.7 Concluding Remarks of Delphi I

To conclude, the results from Delphi I provided significant input to construct a safety culture framework for the Malaysian mining industry. Based on the interview session and analysis conducted using thematic analysis, twenty-four (24) important factors were identified, as shown in Table 4.8. Therefore, Delphi II was conducted in the next session to investigate the consensus among the mining experts on those identified influencing factors of safety culture, as discussed in Section 4.3.

4.3 Results on Delphi II

Delphi Round 2, also known as Delphi II, was conducted to achieve consensus on the influencing factor of safety culture in the mining industry for psychological, organisational, and behavioural dimensions. The email invitation for Delphi II with the Participant Information Sheet was sent by email to all Delphi I experts (Appendix J). 18 out of 21 experts agreed to proceed with Delphi II, which was equivalent to an 85.7% response rate. The sample of the online questionnaire on safety culture and examples of respondents' feedback were appended to Appendix K. The analysis and discussion of Delphi II were discussed in Sections 4.3.3. to 4.3.6.

4.3.1 Results of Validity

The content of these survey instruments was tested by presenting them to the panel of three validators: a Certified Safety and Health Officer, EHS Superintendent, and a Senior Lecturer with 23 years, 17 years, and 19 years of working experience, respectively, in safety culture and survey development. The email invitation and appointment letters as validators for this study were appended in Appendices L and M, respectively. The Validation Feedback Form for Delphi II Round is appended to Appendix N.

Three validators were asked to check the following:

i. Make sure the meaning of each statement is clear and easily understood.

ii. Suggest any changes that might improve how the statements are written.

iii. Suggest items to add or delete from the survey to get better information.

iv. Suggest ways to improve the appearance and format of the survey.

A series of corrections had been made as suggested and commented on by the validators and are appended to Appendix N. These instruments were used to glean the desired information needed in order to facilitate meaningful responses from the Delphi experts. The final version of the questionnaire, as appended in Appendix K, was sent out to the respondents.

4.3.2 Results of Reliability for the Pilot Test

The final version of the questionnaire survey was followed by a pilot test. The results of pilot test were appended in supplementary data upon request. The pilot test was also conducted to check the reliability or internal consistency of the questionnaire. According to Diego (2021), at least 20% of total respondents (21 Delphi experts) can become sample size. Therefore, the questionnaires for Delphi II were distributed to four undergraduate students who had no knowledge about mining or safety culture in order to check the reliability of the questions. In general, reliability tests were conducted after establishing the validity of the content and preliminary data analyses.

When undertaking any research study, consideration must be given to issues of reliability and validity. Reliability is the extent to which a procedure produces similar results under constant conditions on all occasions. There is no evidence of the reliability of the Delphi method. In other words, if the same information were given to two or more panels, would the same results be obtained? To overcome this dilemma, Lincoln and Guba's (1985) criteria for qualitative studies could be applied to help ensure that credible interpretations of the findings are produced. The criteria are based on four major issues: credibility (truthfulness), applicability, auditability (consistency), and conformability. Pressures for prediction convergence (Hill and Fowles 1975) diminish the Delphi's forecasting power and pose a threat to validity. On the other hand, the use of participants with knowledge and interest in the issue may help to improve the Delphi's content validity (Goodman 1987), and the use of multiple rounds of the questionnaire may help to improve the concurrent validity. Nonetheless, it must be mentioned that response rates will ultimately affect the validity of the results.

Therefore, Lee Cronbach invented Alpha in 1951 (Cronbach, 1951), also known as Cronbach's Alpha, to provide a measure of a test's or scale's internal consistency; it is expressed as a number between 0 and 1. Internal consistency refers to the extent to which all of the items in a test measure the same notion or construct, and is thus linked to the test's inter-relatedness (Tavakol and Dennick, 2011). Table 4.9 shows the interpretation of Cronbach's Alpha. It was the most common form to test the measurement scale attitude or internal consistency of the questionnaire, with three, five, or seven choices. This is helpful in increasing the reliability of the questionnaire. The formula used to calculate coefficient Alpha are;

$$\alpha = \frac{R}{R-1}\left(1 - \frac{\sum \sigma_1^2}{\sigma_x^2}\right) \tag{4.1}$$

Description:

R= Number of items

σ_1^2 = Variant items

σ_x^2 = total score variant

Table 4.9 The interpretation of Cronbach's Alpha

Cronbach's Alpha	**Internal Consistency**
α ≥0.9	Excellent
0.9 > α ≥0.8	Good
0.9 >α ≥0.7	Acceptable
0.7>α ≥0.6	Questionable
0.6>α≥0.5	Poor
0.5>α	Unacceptable

Source: Cronbach (1951)

Scale reliability is the correlation between two scores ranging from 0 to 1.00, where a lenient cut-off of 0.60 is common in exploratory research. The generally agreed upon lower limit for alpha is 0.70 (Hair et al., 1998), with a cut-off of 0.80 for a good scale (Lingard, Wakefield, and Cashin, 2011). The adopted pre cut-off alpha for this study was 0.70, and measures below 0.70 were eliminated. Table 4.8 shows the interpretation of Cronbach's alpha. For the pilot test, Cronbach's alpha of 0.84 was obtained, and it had good internal consistency with very reliable questions. The comparison of Cronbach's alpha for the pilot test and Delphi II is shown in Figure 4.7. The details of calculation for Cronbach's alpha for the pilot test and Delphi II were available in supplementary documents.

4.3.3 Analysis on Delphi II

The final version of the questionnaires was sent through email to 21 Delphi I experts, and 18 were completed and sent back to the researcher with a response rate of 87.5% for Delphi II. The responses from the 18 participants were identified and analysed. At this round, the experts were known as Delphi II experts. The questionnaire consists of three main parts. Part 1 is a psychological dimension with 12 questions, followed by Part 2, a situational dimension with 18 questions, and Part 3, a behavioural dimension with 21 questions. The Delphi I experts were asked to rate the influencing factors of safety culture for psychological, situational, and behavioural dimensions based on a five-point Likert scale as to their perceived level of importance (Allen and Seaman, 2007). A rating of "5" on the scale would mean the topic was perceived to be strongly agreeing, a rating of "4" would mean the topic was agreeing, a rating of "3" would indicate the topic was neutral, a rating of "2" would indicate that the topic was disagreeing, and a rating of "1" would mean the topic was strongly disagreeing.

Frequencies were obtained to measure the degree of consensus reached amongst participants regarding the influencing factors of safety culture in the mining industry in Malaysia. The results of Delphi II were reviewed and compiled by the researcher. The median, mean, standard deviation, percentages, and interquartile deviation (IQD) scores of each question were calculated. All statements were examined individually for consensus. In other words, the quantitative results were statistically analysed for each questionnaire to determine whether consensus had been reached for each question or statement using the provided scale for each question or statement.

Data analysis in Delphi II consisted of calculating the percentage of participants who chose a concept name for a description and calculating medians, and Inter Quartile Deviations (IQDs) for the answer to the question on the extent to which the influencing factors of psychological, situational, and behavioural factors fell within the scope of the concept. The IQD indicates the distance between the 25th and the 75th percentiles. The lower the IQD, the greater the consensus among participants. It was decided that consensus on descriptions was reached if a similar concept name was chosen by ≥70% of the experts with an IQD of ≤1 (Rayens & Hahn, 2000). The mathematical formulas involved in this analysis are listed in Table 4.10 below;

Table 4.10 Mathematical formulas involved in Delphi II

Item	Mathematical Symbol	Formula	Consensus reached
Mean	x̄	$\bar{x} = \frac{\sum x_i}{N}$ Where; xi: ith Term in The Data Set N : Number of variables in The Data Set	According to Hasson et al. (2000), highest mean, can be considered as consensus reached.
Median	µ	= (N+1)th / 2 term; when N is odd [Nth / 2 term + (N / 2 + 1) term] / 2 ; when N is even Where; x_i: i_{th} term in the data set N: Number of Variables in The Data Set	According to Lamers et al. (2016), the level of consensus for 5 points Likert's scale be analysed based on median as categorized below; i. Median >3: consensus on agreement with a statement. ii.Median = 3: no consensus on agreement with a statement. iii. Median < 3: consensus on disagreement with a statement.
Standard Deviation	σ	$\sigma = \frac{\sqrt{\sum(x - \bar{x})^2}}{n}$ Where; σ = standard deviation x= each value in the data set x̄ = mean of all values in the data set. N= number of values in the data set	Rayens and Hahn (2000) have used means and standard deviations with a decrease in standard deviations between rounds indicating an increase in agreement.

Table 4.10 Continued

Item	Mathematical Symbol	Formula	Consensus reached
Interquartile Deviation (IQD)	IQD	Q_3-Q_1 or 75%-25%	Spinelli (1983) and Raskin (1994) stated if the IQD was less than 1.00, meaning that items with IQD = 0.00 were considered to have reflected high consensus
Percentage distribution	-	Highest percentage shows consensus	Raskin (1994), McKenna, (1994), Holey et al. (2007) stated more than 60% of responses are generally positive or negative with certain questions.

Source: Hasson et al. (2000), Lamers et al. (2016), Rayens and Hahn (2000), Spinelli (1983), Raskin (1994), McKenna (1994), Holey et al. (2007)

Table 4.11 shows the consensus and the overall level of agreement (strongly agree and agree) for each dimension. The next round (Delphi Round 3) was not required since both consensuses were reached for IQD and level of agreement in Delphi II with more than 60% for the influencing factors of psychological, situational, and behavioural dimensions on safety culture in the mining industry in Malaysia.

Table 4.11 Consensus for each dimension

Dimension	Question	Percentage responses of each consensus (%) with IQD of ≤1	Level of agreement (%) for strongly agree (5) and agree (4)	Consensus reached or not based on		
				Median	IQD	Percentage responses
Psychological	12	83.3%	65.27 %	Yes	Yes	Yes
Situational	18	61.1%	73.15 %	Yes	Yes	Yes
Behavioural	21	61.9%	73.55%	Yes	Yes	Yes

Moreover, in terms of internal consistency or reliability of responses from 18 Delphi II experts, the Cronbach's Alpha obtained was 0.97, which was excellent internal consistency with very high reliability. Figure 4.7 shows the comparison of respondents for the pilot test and 18 Delphi II experts. High internal consistency was achieved due to the fact that the Delphi experts have wide knowledge of mining and safety culture, and the experts carefully rated each of question based on Likert's scale.

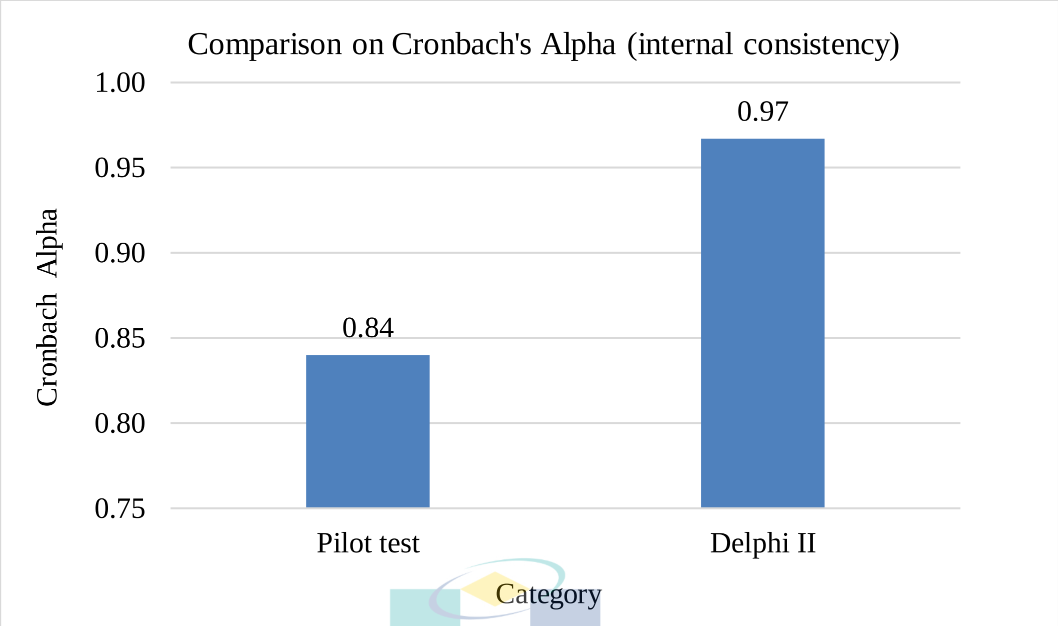


Figure 4.7 Comparison on Internal Consistency

4.3.4 Analysis, Discussion, and Consensus on Psychological Dimension

The influencing factors of safety culture were assessed with the involvement of 18 Delphi II experts. This dimension was reflected in Objective 1, which aimed to investigate the influencing factors of the psychological dimension. The rating was based on 5 Likert scale points, with one being 'strongly disagree' and five being 'strongly agree'. Table 4.12 shows the analysis of the Delphi II survey and individual ratings for Psychological Dimension. Various analyses were discussed by previous scholars to determine the consensus on the Delphi Technique. In this study, the consensus was determined to have been reached if the following criteria were met:

1) Based on Interquartile Deviation (IQD), Spinelli (1983) and Raskin (1994) stated that if the IQD was less than 1.00, items with an IQD = 0.00 were considered to have reflected high consensus. Rayens and Hahn (2000) stated that to achieve consensus, the criterion to achieve consensus was that the IQD should equal one (1) unit, for which more than 60% of respondents should have answered either generally positive or generally negative. Items that had an IQD ≠1 for which the

percentage of generally positive or generally negative responses was between 40% and 60% were determined to indicate a lack of consensus or agreement.

2) Based on percentage responses, Raskin (1994), McKenna (1994), and Holey et al. (2007) stated that more than 60% of the responses were generally positive or negative to certain questions. Holey et al. (2007) opined that consensus is reached when there is an increase in percentage agreements.

3) Based on the median, Rayens and Hahn (2000) have used means and standard deviations, with a decrease in standard deviations between rounds indicating an increase in agreement. According to Lamers et al. (2016), the level of consensus for 5 points Likert's scale be analysed based on the median as categorised below;

    i. Median >3: consensus on agreement with a statement.

    ii. Median = 3: no consensus on agreement with a statement.

    iii. Median < 3: consensus on disagreement with a statement.

4) Rayens and Hahn (2000) have used means and standard deviations, with a decrease in standard deviations between rounds indicating an increase in agreement.

The overall analysis of the comparison on each dimension based on Likert's scale for 18 experts in Delphi II is illustrated in Figure 4.9. The detailed analysis and discussion for each psychological, situational, and behavioural dimensions were further elaborated in Sections 4.3.4 to 4.3.6.

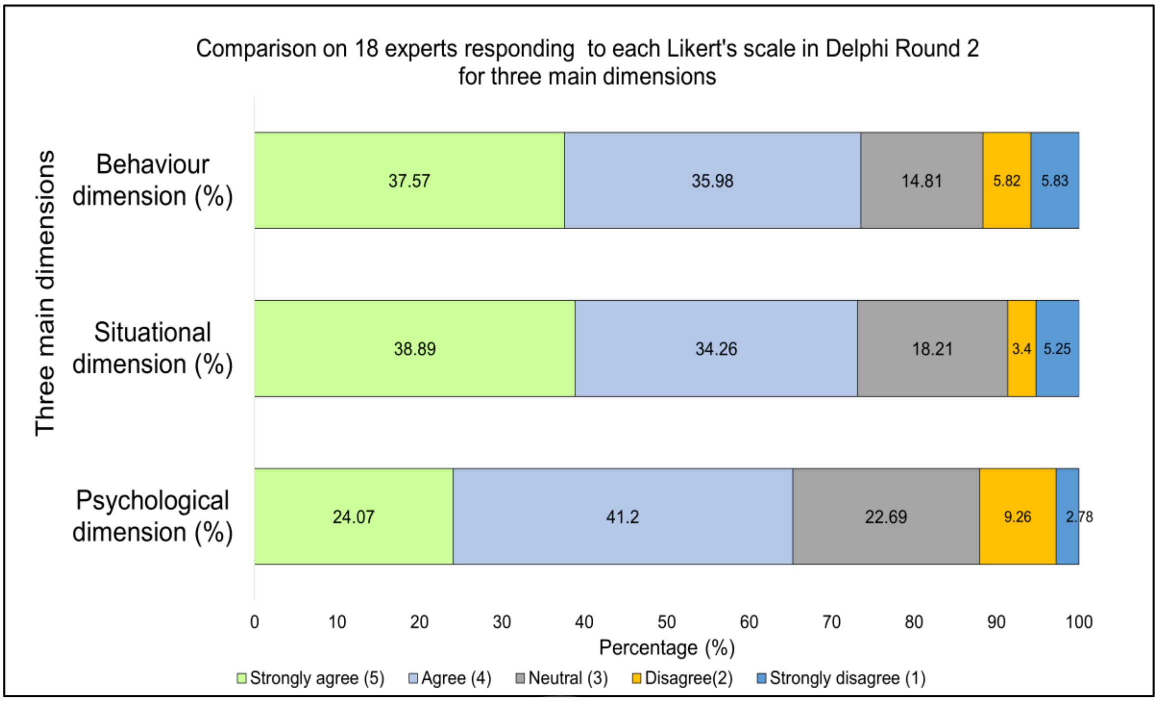


Figure 4.8 Comparison on each dimension based on Likert's scale

Table 4.12 Delphi II survey results and individual ratings for Psychological Dimension

		Psychological Dimension				
Factors	**No.**	**Question**	**Median**	**Mean**	**SD**	**IQD**
1. Management concern/care on workers	1(i)	Top management able to identify and recognise the workers that work under pressure and have intention to take shortcuts about safety.	4	3.33	0.84	1
	1(ii)	Top Management concerns on mine workers involved in mining accidents or any injuries.	4.5	4.22	0.94	1
	1(iii)	Top management alerts on worker's ability to identify the potential hazard and risk while handling machinery or performing the given task.	4	3.72	0.83	0.75
	1(iv)	Top management concerns on the workers that affects or can affect the OH&S performance of company.	4	4.11	1.02	1
	1(v)	Top management listens and gives importance to my opinion for improving work safety.	4	4.06	0.80	1.75
	1(vi)	The safety of workers is a big priority with management where I work.	4	4.22	0.81	1

Table 4.12 Continued

Psychological Dimension						
Factors	**No.**	**Question**	**Median**	**Mean**	**SD**	**IQD**
2. Safety Attitude	2(i)	I feel free to report safety violations where I work.	4	4.06	0.80	0.75
	2(ii)	Completing my work is more important than doing work in safe ways.	2	2.44	1.15	1
3. Job satisfaction	3(i)	Worker's satisfaction in performing the job is the main priority of top management.	4	3.67	0.84	1
4. Health issue	4(i)	Top management concerns and care about worker's health issues, including mental health issues.	4	3.94	0.87	1.5
5. Peer influence	5(i)	My colleagues point out each other's deficiencies in a work safety.	3	3.06	1.11	0.75
	5(ii)	I alert my colleagues who act contrary to work safety rules.	4	4.00	0.69	0

By applying the interquartile deviation (IQD) to determine whether the influencing factors reached consensus or not, three (3) factors, namely Safety Attitude, Job Satisfaction, and Peer Influence, reached consensus with the IQD cut-off (IQD ≤1) score set to reach consensus, as shown in Table 4.12. However, for the factor of Management Concern/Care for Workers, only one item, i(v) was not achieved by consensus. The rest reached consensus with the IQD cut-off (IQD ≤1). For the Health Issue factor, consensus was not reached with an IQD of 1.5. For IQD, 83.3% reached consensus with the IQD cut-off (IQD ≤1).

Based on Table 4.12, 10 out of 12 questions for psychological dimensions obtained a median > 3, which means consensus on agreement with the statement was 83.3%. One question 2(ii) under Safety Attitude obtained a median of 2, which means consensus on disagreement with a statement. For question Item5(i) under the Peer Influence factor, the median was equivalent to 3, meaning there was no consensus on agreement with a statement. 83.3% of Delphi II experts achieved consensus, even though two questions did not.

Moreover, in terms of the percentage of rating distribution for the psychological dimension (percentage responses), the funnel chart in Figure 4.9 shows a total of 64.81 % came from strongly agree and agree responses. Only 9.72% and 2.78%, respectively, were rated as disagreeing and strongly disagreeing on the overall 12 questions related to the Psychological dimension. Therefore, it indicates a strong agreement or consensus on the items for each factor for Psychological dimension.

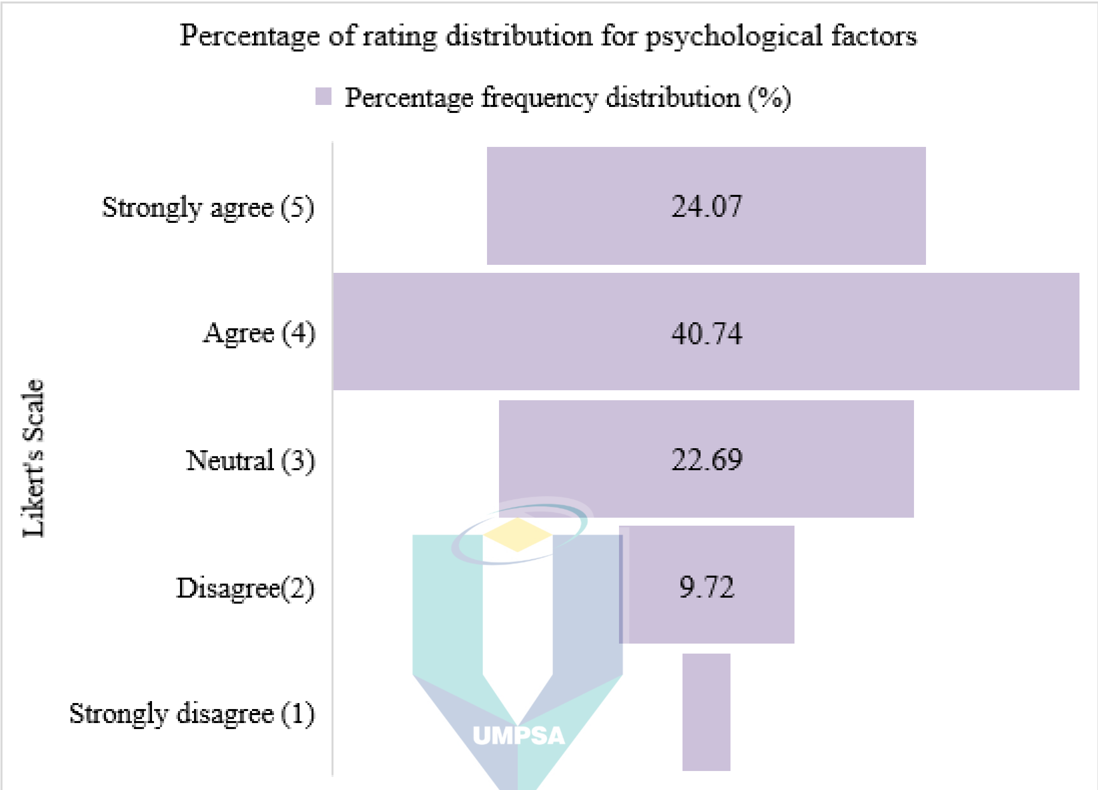


Figure 4.9 Funnel chart on percentage of rating distribution for Psychological Dimension

Based on the standard deviation, Rayens and Hahn (2000) have used means and standard deviations, with a decrease in standard deviations between rounds indicating an increase in agreement. Based on Table 4.12, the means obtained were between 2.44 and 4.22, and the standard deviation was less than 1.00.

For Psychological dimension, the study successfully identified that (1) Management Concern/Care for Workers, (2) Safety Attitude, (3) Job Satisfaction, (4) Health Issues, and (5) Peer Influence factors are important in creating a good safety culture. According to Cooper (2000), the psychology factors are close to the concept of "How People Feel". It represents either individual or group values, attitudes, and perceptions about safety. Safety attitude, according to Hu et al. (2011) and Wang et al. (2018), is the psychological view of a safe culture, processes, and accident prevention.

The experts agreed that safety attitude has a substantial impact on influencing a positive safety culture at work, based on Delphi I and II findings. Mine employees will have a negative psychological status as a result of their poor safety attitude. According to Jiang et al. (2019), poor physiological state and inadequate safety behaviour are examples of safety attitudes among 27 coal mining firms. One of the challenges in implementing a safety culture is miners' lack of knowledge about safety (Lööw et al. 2019).

Job satisfaction is also a key psychological component in fostering a positive workplace safety culture. Mine personnel must be satisfied with their work and perform it with a high level of responsibility. Job satisfaction may be obtained by demonstrating the supervisor's or top management's leadership in equitably distributing responsibilities among the workers and matching each worker's skills. It's difficult because small-scale mining operations prefer to minimise labour costs by hiring unskilled employees to undertake mining tasks.

Another major worry raised by Delphi experts was the health of mine workers. They think that if workers are in their best fit, they will be more focused at work, hence near-misses or workplace accidents will be prevented. Mine employees' psychological well-being is strongly linked to their physical health. Workers that are unwell will have a detrimental impact on the company, such as interruptions in daily output.

Peer influence is another component that has an impact on the psychological aspect of safety culture. Rubin et al. (2020) stated that peer influence and commitment were critical in fostering a healthy safety culture. Miners that have a negative peer impact will have a mining catastrophe. This conclusion was backed up by a study of 233 coal miners conducted over the course of ten months. Jiang et al. (2020) performed a study of 82 coal mine businesses and found that peer or colleague influence had a significant impact on the development of a safety culture among miners.

To conclude, the agreement or level of consensus was achieved with an 83.3%, obtained median >3, and IQD cut-off (IQD $\leq$1). The percentage of rating distribution also achieved 64.81% for the psychological dimension. Therefore, the researcher did not proceed with Delphi Round 3 since the consensus of agreement was achieved for the psychological dimension. It was supported by Holey et al. (2007), who stated that if more than 60% of responses are generally positive, the consensus is reached. Therefore, these five influencing factors of the psychological dimension, namely (1) Management Concern/Care for Workers, (2) Safety Attitude, (3) Job Satisfaction, (4) Health Issues, and (5) Peer Influence factors, have a great influence on the psychological dimension of safety culture and were used as an input to develop a questionnaire for the Analytical Hierarchy Process (AHP) method.

4.3.5 Analysis, Discussion, and Consensus on Situational Dimension

Objective (2) was to investigate the influencing factors of the situational dimension of safety culture. Ten influencing factors were involved, namely; (1) Safety Policy, (2) Safety Audit, (3) Safety Rules, (4) Competent SHO, (5) Safety Education, (6) Safety Programme, (7) Safety Planning, (8) Medical Surveillance, (9) Safety Competency, and (10) Safety Signage. These influencing factors of safety culture were assessed with the involvement of 18 Delphi II experts. By using 5 points of Likert scale, with one being 'strongly disagree' and five being 'strongly agree', the Delphi II results and individual ratings for Situational Dimension are shown in Table 4.13.

Table 4.13 Delphi II results and individual ratings for situational dimension

Situational Dimension						
Factors	**No.**	**Question**	**Median**	**Mean**	**SD**	**IQD**
1. Safety policy	1(i)	The established OH&S policy and OH&S objectives of the mining company is compliance with OSH legal requirement and others requirement set up by government.	5	4.39	1.04	1
	1(ii)	All workers understand and comply with the relevant OH&S policies/procedures, legal requirement and other requirement of company while performing their job	4	3.94	1.00	0.75
2. Safety Audit	2(i)	All the requirements and outcomes of OH&S management system, including the OH&S policy and OH&S objectives of company will undergo an internal audit	4	4.00	1.14	2
	2(ii)	All the requirements and outcomes of OH&S management system, including the OH&S policy and OH&S objectives of company will undergo an external audit.	4	4.00	1.08	1.75
	2(iii)	The audit results are well reported and shared to all level of management and workers	4	3.72	1.07	1

Table 4.13 Continued

Situational Dimension						
Factors	**No.**	**Question**	**Median**	**Mean**	**SD**	**IQD**
3. Safety rules	3(i)	Top Management provides a clear standard operating procedure (SOP) to workers in handling machinery and handling chemical.	4	4.06	1.11	1.75
	3(ii)	All workers use proper Personal Protective Equipment (PPE) while performing job (such as noise, working at height, handling chemical, use machine etc.)	4	3.94	1.21	1
4. Competent SHO	4(i)	Providing a competent Safety and Health Officer in supporting the OH&S management system, including the OH&S policy and OH&S objectives.	4	4.22	0.81	1
5. Safety /education	5(i)	All workers are provided with the relevant training on OSH legal requirement and other requirement.	4	3.72	1.18	0.75
6.Safety programme	6(i)	All the safety programmes, activities or events are intended to support the OH&S policy and OH&S objectives of the mining company	4	4.11	0.90	1
7. Safety planning	7(i)	Top Management responsible to take action in addressing nonconformities and continually improve its OH&S performance is important to construct safety culture.	4	4.11	1.02	1
	7(ii)	Top Management responsible in identifying, solving and providing preventative action related to ergonomics problem facing by workers	3	3.61	1.20	2
	7(iii)	Top Management implement the engineering controls, reorganization of work, or both at workplace	4	3.83	0.99	0.75
8. Medical surveillance	8(i)	Top Management provides Occupational Health Doctor to handle health issues among worker including mental health issue	3.5	3.28	1.45	1
	8(ii)	Top Management provides annual medical check up to workers	4	4.11	0.96	1.75
9. Safety competency	9(i)	Top management consider the previous educational background of workers to create safety culture at current workplace	4	3.89	1.13	1.75
	9(ii)	Top management consider the previous working experience of worker to create a safety culture at current workplace	4	4.00	1.19	1.75
10. Safety signage	10(i)	Top management provides a clear safety signage at mine site and working area.	5	4.72	0.57	0

By applying the interquartile deviation (IQD) to determine whether the influencing factors reached consensus or not, 11 out of 18 items reached consensus with the IQD cut-off (IQD ≤1) score set equivalent to 61.1%, as shown in Table 4.13. Four influencing factors, namely (1) Safety Policy, (4) Competent SHO, (5) Safety Education, (6) Safety Programme, and (10) Safety Signage, reached consensus with the IQD cut-off (IQD ≤1) score set. Seven (7) items were recorded with an IQD > 1 which came from items 2(i) and 2(ii) for Safety Audit, item 3(i) for Safety Rules, item 7(ii) for Safety planning, item 8(ii) for Medical Surveillance, and items 9(i) and 9(ii) for Safety Competency. These items or factors did not achieve consensus. However, according to Lamers et al. (2016), the level of consensus for 5 points Likert's scale can be analysed based on the median, as categorised below;

i. Median >3: consensus on agreement with a statement.

ii. Median = 3: no consensus on agreement with a statement.

iii. Median < 3: consensus on disagreement with a statement.

17 out of 18 questions for Situational Dimensions obtained a median of > 3, which means consensus on agreement with the statement was 94.4%. Only one question 7(ii) under Safety Planning obtained a median of 3, which means there was no consensus on agreement with a statement. Furthermore, in terms of the percentage of rating distribution for the Situational Dimension (percentage responses), the funnel chart in Figure 4.10 shows a total of 73. 15% came from strongly agree and agree responses. Only 3.40% and 5.25%, respectively, were rated as disagreeing and strongly disagreeing on the overall questions related to the Situational Dimension. Therefore, it indicates strong agreement or consensus on the items for each factor in the Situational Dimension.

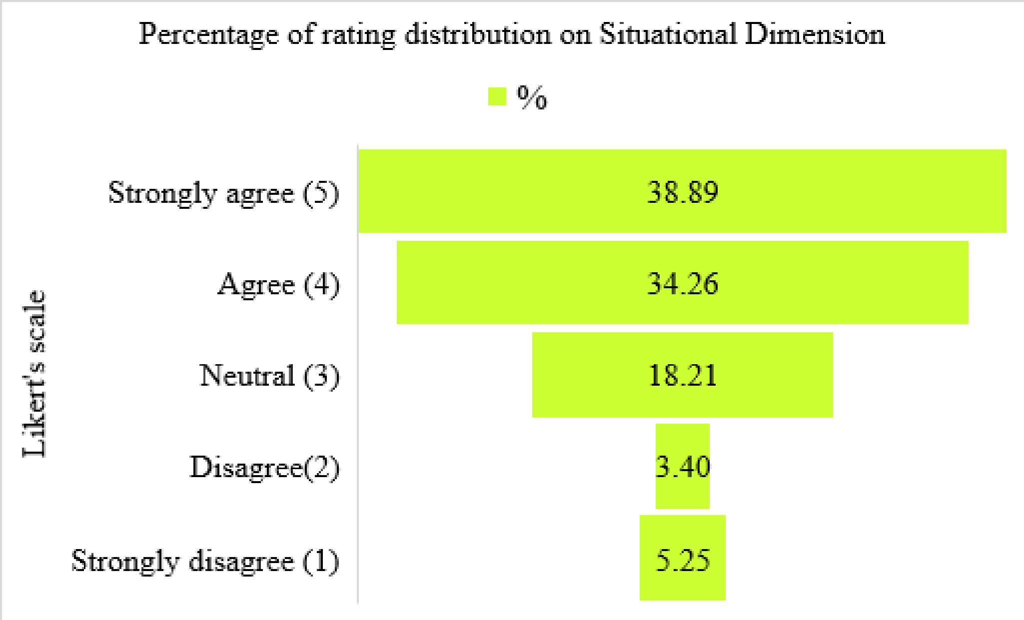


Figure 4.10 Funnel chart on percentage of rating distribution for Situational Dimension

To conclude, the influencing factors of Situational Dimension achieved consensus with (IQD ≤1 of 61.1% and a median > 3 of 94.4%. and the percentage distribution was 73.15%. Moreover, the mean and standard deviation did not have a significant impact on the determination of consensus in this study. Based on the standard deviation, Rayens and Hahn (2000) have used means and standard deviations, with a decrease in standard deviations between rounds indicating an increase in agreement. Based on Table 4.13, the means obtained were between 3.28 and 4.72, and the standard deviation was between 0.57 and 1.20. Since the researcher did not proceed with Delphi Round 3, consensus based on mean and standard deviation can be neglected. Only IQD, median, and percentage distribution were significant in this analysis. Ten (10) influencing factors of Situational Dimension were further investigated and used as input for the questionnaire of the Analytical Hierarchy Process (AHP) method.

Moreover, this study also successfully investigated the factors that contribute to a sustainable situational safety culture in the Malaysian mining industry. The experiences and points of view of the mining experts have been placed in ten sub-themes: (1) Safety Policy, (2) Safety Training/Safety Education, (3) Safety Programme, (4) Safety Rules include Wearing PPE, (5) Safety Planning, (6) Safety Competency (7), Safety Audit, (8) Safety Signage, (9) Competent SHO/Leader, and (10) Workers' Health. The key findings of the situational safety culture system in the Malaysian mining industry are illustrated in Figure 4.11. It does not show the rank of factors. Later on, these factors were ranked or prioritized by using AHP.

Safety culture was built on three main foundations (Schein, 1989), namely: (1) Psychological or people factor, (2) Situational/working environment/organisation factor, and (3) Behavioural factor. Thus, it is understood that the organisation's safety culture falls under the situational factor or working environment factor. In this study, the researchers referred to the situational or working environment factor as a compliance factor, which means the responsibility of the top management itself (mine owner or mine operator) to provide a safe working environment, ensure a culture of safety exists among the mine workers, and most importantly, is the management must ensure all related safety follows the government's needs. This study revealed the ten factors needed to construct a safety culture in mining organisations by interviewing mining experts who have vast experience in the mining industry in Malaysia.

All the mining experts agreed that the safety policy must be clear at the top management level. The mine owner or top management plays an important role in initiating a safety culture in their organisation with the support of their mine workers. The efforts of top management to make safety culture their main priority are important, such as having a good safety policy, safety training, and a safety programme. The management also must set a good example, which will motivate the employees to participate in and support any activities that are organised by top management.

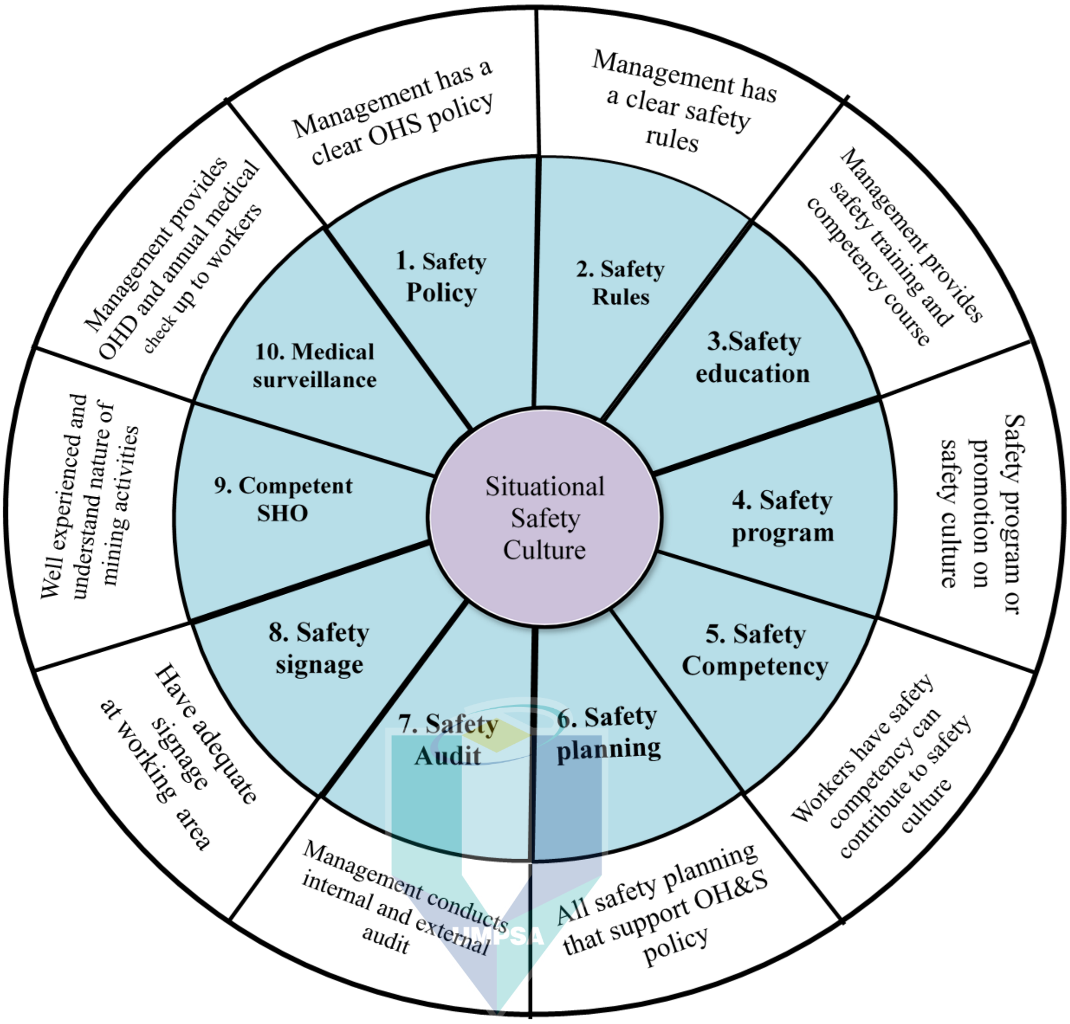


Figure 4.11 Situational safety culture factors for the Malaysian mining industry based on Delphi I and Delphi II

One of the interesting findings in this study was the status of safety culture awareness and practises among mining organisations in Malaysia, as highlighted by the HSE Manager (R2). A huge gap in safety culture awareness between small-scale and large-scale mine operations is quite worrying at 30% and up to 80%, respectively. Small-scale mine operations are eager to have a quick rate of return, which therefore drives them to neglect the safety aspects. However, in this case, the gap can be reduced if the mine owner of a small-scale mine operation is ready to change their mindset and understand that the safety issue is part of their investment. For example, if there is an accident, their production will face problems due to a lack of manpower or mineworkers.

Therefore, they required a clear safety policy with good safety planning, and at least all the workers understood the importance of safety rules while handling any machinery and tried to avoid any injuries or near misses while working at the mine site.

In addition, the top management, either for small- or large-scale mine operations, is also required to provide clear OH&S and safety rules because it will help the mine workers become more disciplined and safe as part of their habits and turn them into responsible mine workers. Large-scale mine operations have many advantages and can create a good safety culture in organisations easier, as required by the government, because they have strong financial resources and are able to provide and organise safety programmes for their employees. However, the lack of employee participation may also hinder the effectiveness of the safety culture in mining organisations (Eskandari et al. 2017).

4.3.6 Analysis, Discussion, and Consensus on Behavioural Dimension

Twenty-one (21) questions were constructed for the Behavioural Dimension. This dimension was reflected in Objective 1 which aimed to investigate the influencing factors of Behavioural dimension: (1) Management action and responsibility, (2) Safety communication, (3) Leadership, (4) Safety training, (5) Safety awareness, (6) Safety reporting, (7) Safety promotion, (8) Enforcement of safety rules, and (9) Reward and punishment. The rating was based on 5 Likert scale points with one being ‘strongly disagree’ and five being ‘strongly agree’. Table 4.14 shows the analysis of the Delphi II survey and individual ratings for the Behavioural Dimension.

Table 4.14 Delphi II results and individual ratings for Behavioural dimension

Behavioural Dimension						
Factors	**No.**	**Question**	**Median**	**Mean**	**SD**	**IQD**
1. Management action and responsibility	1(i)	Top Management committed to ensure each level of workers able to understand, apply and support the established OH&S policy and OH&S objectives of the company.	4	4.00	1.03	1.75
	1(ii)	The organization should examine the resources required (e.g. financial, human, equipment, infrastructure) to achieve OH&S policy and OH&S objectives of the company.	4	3.94	1.06	1
	1(iii)	The Top Management has allocation or budget to support the intended outcome of OH&S policy and OH&S objectives of the company	4	4.00	1.19	1.75
	1(iv)	Top Management shows the commitment by providing the resources needed for the establishment, implementation, maintenance and continual improvement of the OH&S management system.	4	4.00	1.19	1.75

Table 4.14 Continued

Behavioural Dimension						
Factors	**No.**	**Question**	**Median**	**Mean**	**SD**	**IQD**
	1(v)	Establishing a planned response to emergency situations, including the provision of first aid are not important in mining industry.	2	2.61	1.65	3
2. Safety communication	2(i)	The OH&S policy, objectives, requirement and information are well documented and easily accessed by workers	4	3.83	0.99	0.75
	2(ii)	Communicating relevant safety information to contractors, visitors, emergency response services, government authorities and the local community is important to create a safety culture.	5	4.44	1.04	1
	2(iii)	The dissemination and communication of OH&S information is consistent and reliable with information generated within the OH&S management system.	4	3.89	1.08	0.75
3. Leadership	3 (i)	Appointing competent Safety and Health Officer in supporting the OH&S management system, including the OH&S policy and OH&S objectives.	4	3.83	1.04	0
4. Safety training	4(i)	Top Management is committed to have competent workers by providing adequate and appropriate education and training.	4.5	4.11	1.18	1
	4(ii)	Determining competence requirements, training needs, training and evaluating training for workers are important to construct safety culture.	4.5	4.33	0.84	1
5. Safety awareness	5(i)	All workers give full commitment and comply with the relevant OH&S policies/procedures, legal requirement and other requirement of company while performing their job.	4	4.00	0.97	2
	5(ii)	Each level of workers is aware and have clear understanding on the OH&S policy and OH&S objectives of company.	4	3.56	1.10	1
	5(iii)	Workers are able to apply and comply relevant OSH legal requirement and other requirement to do their job.	4	3.56	0.92	1
	5(iv)	Does eliminate hazards and reduce OH&S risks are important for safety culture?	4.5	4.28	1.02	1
6. Safety reporting	6(i)	All incidents, non-compliance, and non-conformity are investigated quickly in order to improve safety at the workplace as soon as possible. Preventive reports are recommended for future reference.	4.5	4.17	1.10	1

Table 4.14 Continued

Behavioural Dimension						
Factors	**No.**	**Question**	**Median**	**Mean**	**SD**	**IQD**
	6(iii)	Improving the occupational health and safety culture, such as by extending competence related to occupational health and safety beyond requirements or encouraging workers to report incidents in a timely manner.	4.5	4.06	1.21	1.75
7. Safety promotion	7(i)	Do safety activities or events actively promote a safety culture in the mining industry?	4	4.00	1.03	1
8. Enforcement on safety rules	8(i)	Do wearing proper Personal Protective Equipment (PPE) and understanding the instructions to wear PPE actively promote safety culture in mining industry?	5	4.33	0.91	1
9. Reward and punishment	9(i)	Top Management acknowledges and rewards the workers based on their contribution and commitment to the OH&S management system, including the benefits of improved OH&S performance for the company.	4	3.72	1.18	0.75

By applying the interquartile deviation (IQD) to determine whether the influencing factors reached consensus or not, 14 out of 21 items reached consensus with the IQD cut-off (IQD ≤1) score set, which is equivalent to 66.7%, as shown in Table 4.14. Six influencing factors, namely Safety Communication, Leadership, Safety Training, Safety Promotion, Enforcement of Safety Rules, and Reward and Punishments were reached consensus with the IQD cut-off (IQD ≤1) score set. Among them, the Leadership factor has the strongest consensus with IQD = 0 followed by Safety Communication, Safety Training, Reward and Punishment, Safety Promotion, and Wearing PPE. For the median, 20 out of 21 items for Behavioural dimensions obtained a median > 3, which means consensus on agreement with the statement was equivalent to 94.4%. Only one question 1(v) under Management Action and Responsibility was obtained with a median =2, which means there was no consensus on agreement with a statement. Furthermore, in terms of the percentage of rating distribution for the Behavioural Dimension (percentage responses), the funnel chart in Figure 4.12 shows a total of 73.55% which came from strongly agree and agree responses. Only 5.82% of the respondents disagreed and strongly disagreed, respectively, on the overall list of questions or items related to the Behavioural dimension. Therefore, it indicates strong agreement or consensus on the items for each factor in the Behavioural dimension.

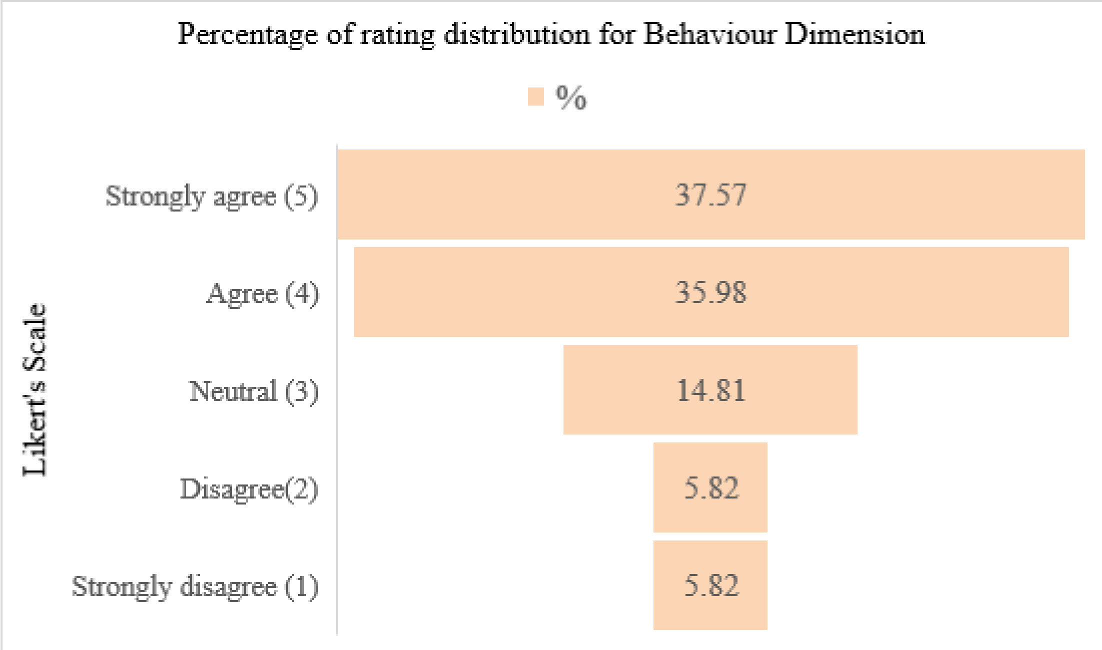


Figure 4.12 Funnel chart on percentage of rating distribution for Behavioural dimension

To conclude, the influencing factors of Situational Dimension achieved consensus (IQD ≤1 was 67.6%, median > 3 was 94.4%. and the percentage distribution was 73.55 %. Based on Table 4.14, the means obtained were between 3.28 and 4.72, and the standard deviation was between 0.57 and 1.20. Moreover, the mean and standard deviation do not have a significant impact on the determination of consensus in this study. Based on the standard deviation. Rayens and Hahn (2000) have used means and standard deviations, with a decrease in standard deviations between rounds indicating an increase in agreement. Since the researcher did not proceed with Delphi Round 3, consensus based on mean and standard deviation can be neglected. Only IQD, median. and percentage distribution were significant in this analysis. For the Behavioural dimension, nine (9) factors were successfully identified based on the Delphi Method, namely: (1) Management Action and Responsibility, (2) Safety Communication, (3) Leadership, (4) Safety Training, (5) Safety Awareness, (6) Safety Reporting, (7) Safety Promotion, (8) Wearing PPE, (9) Reward and Punishment, as shown in Figure 4.13. All these factors were later further investigated, and this information was used as an input for the Analytical Hierarchy Process (AHP) method.

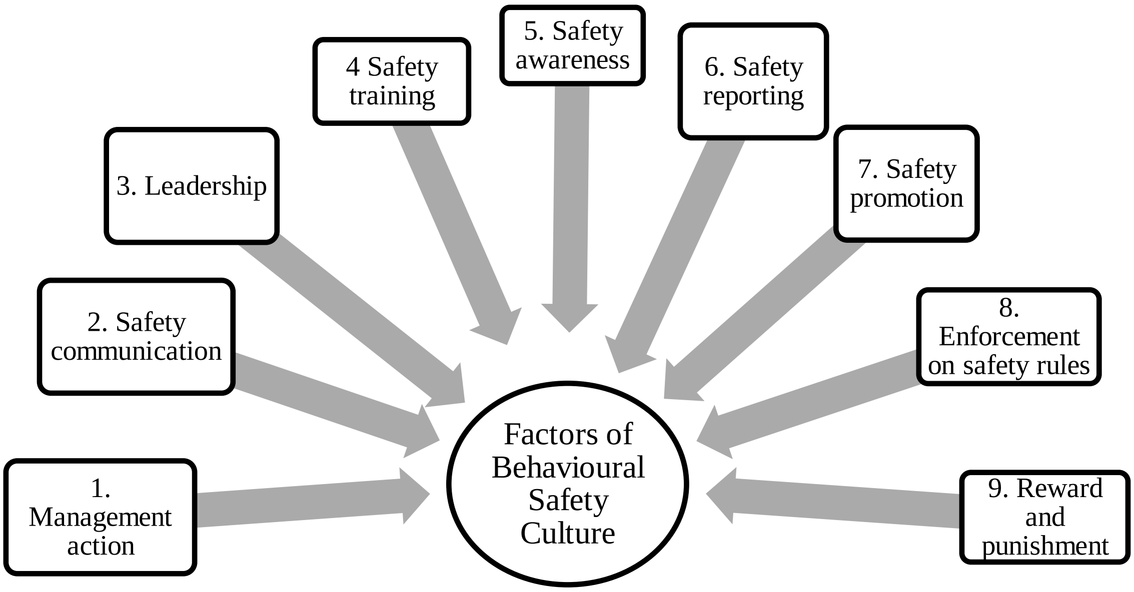


Figure 4.13 Nine factors of behavioural safety culture in the Malaysian mining industry

The management action and responsibility were crucial in developing a good safety culture in the Malaysian mining industry. Previous scholars stated that Behaviour was defined as "What People Do", such as safety-related actions and behaviours and safety leadership (Cooper, 2000). It shows that actions must work together with good leadership to ensure the direction to create a good safety culture can be achieved. The process of creating a good safety culture takes time. Therefore, it is also important to include mutual cooperation between employers and employees to ensure safety is their main priority and to help each other create a safe working environment. To the best of our knowledge, this is the first Delphi study focusing on the behavioural safety culture in the Malaysian mining industry. Delphi was successfully completed in two phases with the help of mining experts. According to the Delphi I and II investigations, nine major factors have a significant influence on constructing a good behavioural safety culture in the Malaysian mining industry, as shown in Figure 4.13.

Management action is the key element to driving the implementation of a safety culture in the mining industry (Jiang et al. 2020). The management should be aware that safety is the kind of investment that ensures all the employees can work in a convenient working environment that prioritises safety issues at all times. To make it a success, the top management of mining companies must provide good safety communication, such as a safety notice board, email, memo, reporting system, and safety briefing. This is important to ensure all safety issues or safety information can be effectively disseminated effectively to all levels of employees and avoid miscommunication among them. Thus, the causes of mining accidents can be reduced or prevented if the top management is aware on the importance of inculcating a behavioural safety culture at the mining workplace by getting full cooperation from all levels of employees to make it successful Moreover, safety training is important to educate the employees on the importance of safety at the workplace and increase awareness among them. Enforcement of wearing complete Personal Protective Equipment (PPE) while handling machines or heavy-duty machines and transportation is also important to prevent any near- misses, incidents, or even mining accidents or disasters. The culture of wearing PPE must be emphasised, especially at mining sites.

4.3.7 Concluding remarks

Based on the findings of the Preliminary study, Delphi I and Delphi II, the summary of influencing factors and definitions for each factor are illustrated in Figure 4.14. All these factors are prioritised by using the Analytical Hierarchy Process (AHP) and validated by Focus Group Discussion (FGD) and a case study at mining company X, as discussed in Sections 4.5 and 4.6.

Influencing Factors of Safety Culture for Mining industry in Malaysia

3 main dimensions and 24 factors of safety culture

Psychological dimension

1. Management care on workers
2. Safety Attitude
3. Job Satisfaction
4. Health of worker
5. Peer influence

Situational dimension

1. Safety Policy
2. Safety Audit
3. Safety Rules
4. Competent Safety Health Officer
5. Safety education
6. Safety program
7. Safety planning
8. Medical surveillance
9. Safety competency
10. Safety signage

Behaviour dimension

1. Management action and responsibility
2. Safety communication
3. Leadership
4. Safety training
5. Safety awareness
6. Safety reporting
7. Safety promotion
8. Enforcement on safety rules
9. Reward and punishment

Definitions

Psychological
"how people feel"

Psychological Dimension

No.	Factors	Definition
1.	Management Care for Workers	Refers to management's interest with workers' psychological conditions as they relate to their work environment and performance.
2.	Safety Attitude	Refers to mine workers' psychological attitudes regarding workplace safety culture, procedures, and accident prevention.
3.	Job Satisfaction	Refers to a worker's satisfaction with the task he or she has been assigned without undermining the employer's efforts.
4.	Health of Workers	Refers to a worker's physical and mental ability to do the task at hand.
5.	Peer Influence	Refers to co-workers or colleagues who have a significant impact (good or bad) on the development of a workplace safety culture.

Figure 4.14 Key influencing factors of safety culture for Malaysia mining industry.

Situational *"What organization has"*

Situational Dimension		
No.	Factors	Definition
1.	Safety Policy	Refers to the mining companies stated OH&S policy and OH&S objectives, which include compliance with OSH legal requirements and other government-imposed requirements.
2.	Safety Audit	Refers to the auditor's internal and external audits and ensures that all records are appropriately documented for future reference.
3.	Safety Rule	Refers to all of the mining company's developed standard operating procedures, guidelines, rules, regulations, and safety practises, which must be followed by all mine personnel and do not conflict with local authorities' and government's requirements.
4.	Competent SHO	SHO is well-trained and experienced in mining operations and activities, and referred to as a competent SHO.
5.	Safety Education	Refers to any type of education and training offered by management to improve employees' safety skills, knowledge, and competency.
6.	Safety Programme	Refers to current and completed programmes, events, and activities such as safety awareness week, safety first, and others.
7.	Safety Planning	Refer to all short- and long-term plans, as well as ongoing safety planning offered to employees by senior management. For future reference, everything forthcoming and completed planning must be carefully documented.
8.	Medical Surveillance	Top management assigns an Occupational Health Doctor to evaluate employee health and safety to ensure that employees are physically and psychologically capable of doing their duties.
9.	Safety Competency	Refers to employees' prior safety knowledge and work experience, as well as any ongoing safety training or education they get to improve their professional abilities and competences.
10.	Safety Signage	Refers to any chemical signage, working station signage, mining site signage, or safety promotion signage that is used to keep personnel informed of impending dangers.

Behavioural *"What people do"*

Behavioural Dimension		
No.	Factors	Definition
1.	Management action and responsibility	Refer to top management's commitment to ensuring that all employees follow the company's safety policies and rules.
2.	Safety communication	Refer to management's communication channels, such as email, memos, safety briefings, bulletin boards, and reporting systems to guarantee dual communication between employees and employers.
3.	Leadership	Refer to a well-trained and experienced SHO, supervisor who is capable of effectively leading and supervising personnel.
4.	Safety training	Refers to management's commitment to offer staff sufficient training and competence courses.
5.	Safety awareness	Refers to employee knowledge of the significance of safety and the culture of safety at work, as well as comprehension of safety policies. Standard Operating Procedures (SOPs), standards, and regulations
6.	Safety reporting	To report misbehaviour or unethical concerns involving workers or supervisors, use the management-provided method, which may be used either offline (manually) or online.
7.	Safety promotion	Any promotion, including activities and programmes created by management to instil a safety culture at work, such as safety weeks, safety films, safety signs, safety talks, and safety seminars.
8.	Enforcement on safety rules	Refer to the established SOP, regulations, and standards, which must be adhered to by all levels of personnel.
9.	Reward and punishment	Refer to bonuses to reward excellent employees, or any misbehaviour or unethical behaviour by employees must be penalised.

Figure 4.15 Continued

4.4 Results on Analytical Hierarchy Process (AHP) Method

The Analytical Hierarchy Process (AHP) method was used to prioritise the influencing factors of psychology, situational, and behavioural safety culture.

4.4.1 List of AHP Experts

The number of AHP respondents was based on recommendations and suggestions from previous scholars in literature. The key advantage of AHP over other Multiple Criteria Decision-Making (MCDM) methods is that it does not require a statistically significant (large) sample size to produce sound and statistically robust results (Doloi, 2008). Some scholars argue that this is because AHP is a subjective method for studying a specific issue, hence a large sample size is not necessary (Lam and Zhou, 1998). In fact, others argue that as AHP is based on expert evaluations, even one qualified expert's opinion is usually representative (Tavares and Parry-Jones, 2008).

Furthermore, applying AHP to a large sample size study could be ineffective since 'cold-called' experts are more likely to provide arbitrary responses, undermining the consistency of the assessments (Cheng, Li, and Ho, 2002). One of the reasons for AHP's success is its ability to manage a small number of participants. There is no fixed minimum sample size for AHP analysis, according to the extant literature on AHP applications in management and engineering studies (Cheng et al. 2002). In other studies, sample numbers ranging from 4 to 9 people are recommended (Amos, Albert, Ernest, Effah, & Emmanuel, 2019). Therefore, in this study, five volunteered respondents agreed to participate, and they met the qualifying criteria, such as having an extensive experience in the mining industry with more than 10 years.

The details of the curriculum vitae were available in supporting documents. The panels were briefed on the overview of the study and the objectives of the AHP study. An example of an email invitation, an official appointment letter from faculty, and a detailed description of the AHP study, and the AHP Questionnaire on Safety Culture were appended in Appendix O, Appendix P, Appendix Q, and Appendix R, respectively. The respondents who agreed to participate understood that this method is voluntary and time-consuming. The list of volunteered respondents for AHP is shown in Table 4.15.

Table 4.15 Background of the mining experts for AHP study and their locality

No.	Position	Locality	Working experience (years)	Expertise
1.	Mining Manager	Sabah	20	Mine operation Mine safety
2.	Senior Geologist	Pahang	15	Mine operation, Mine safety
3.	Senior Mining Engineer	Pahang	15	Mine operation, Mine safety
4.	Head of Researcher for Mineral Development	Perak	25	Mineral development Mine operation
5.	Mine Owner	Pahang	15	Mine Development Mine business Mine Safety

4.4.2 Process flow of AHP

AHP consists of a few main steps, such as: (1) Determine goal of study, (2) Set-up the main criteria and sub criteria, (3) Construct the hierarchy, (4) Make pair-wise comparisons, (5) Calculate indicator weight, (6) Consistent inspection, and (7) Aggregate indicator weight. The details of the process flow for AHP are discussed in Subtopic 3.5.2 in Chapter 3.

4.4.3 Data input and validation of AHP Questionnaire

The data input was solely dependent on the analysis of Delphi I and Delphi II for the psychological, situational, and behavioural dimensions of safety culture. The draft of the AHP questionnaire was validated first by a professor from a local university who has extensive experience and is an expert in utilising AHP in his research. The email invitation, appointment letter, and feedback from validators were appended in Appendices S, T, and U respectively. Overall, the AHP questionnaire consists of five main parts, as shown in Table 4.16. Once the comments were received, the correction was made before distributing it to all AHP respondents through email. The respondents were given three weeks to give their feedback. The Participant Information Sheet for AHP and the final version of the AHP Questionnaire are appended to Appendices R and S, respectively.

Table 4.16 The section of AHP Questionnaire

Part	Item of Questionnaire	No. of questions	Sub -criteria	Main output
1.	Respondents' Background	3	-	-
2.	Main criteria	3	Psychological dimension Situational dimension Behavioural dimension	Obtained prioritised dimension for safety culture
3.	Sub-criteria for Psychological dimension	10	1. Management care on workers 2. Safety attitude 3. Job satisfaction 4. Health of worker 5. Peer influence	Obtained prioritised psychological factors for safety culture
4.	Sub-criteria for Situational dimension	45	1. Safety policy 2. Safety Audit 3. Safety rules 4. Competent SHO 5. Safety education 6.Safety programme 7. Safety planning 8. Medical surveillance 9. Safety competency 10. Safety signage	Obtained prioritised behavioural factors for safety culture
5.	Sub-criteria for Behavioural dimension	36	1. Management action and responsibility 2. Safety communication 3. Leadership 4. Safety training 5. Safety awareness 6. Safety reporting 7. Safety promotion 8. Enforcement on safety rules 9. Reward and punishment	Obtained prioritised behaviour factors for safety culture

4.4.4 Result and Analysis on Prioritised Factor of Safety Culture

The first step and second steps of AHP were to determine the main goal for the AHP and setting up the criteria, respectively. Therefore, the main goal of AHP was to prioritise main and sub-criteria or factors, for each psychology, situation, and behaviour of the safety culture dimensions. The third and fourth steps were setting up the hierarchy and pairwise comparison. For this purpose, an example of how to calculate the Consistency Ratio (CR) for the Main Criteria of Safety Culture *(3x3 matric*) is shown below;

(a) Insert the respondents' feedback and calculate the geomean, as shown in Table 4.17. The example of the AHP questionnaire is appended in Appendix R.

Table 4.17 Results of the Geomean

	Main Criteria		
Respondent	**Question 1**	**Question 2**	**Question 3**
R1	1	1	1/9
R2	1/9	1/5	9
R3	1/7	7	9
R4	9	1/9	1/9
R5	1	1/7	1/6
Geomean	0.678	0.467	0.699

(b) Insert the geomean into 3x3 matric and calculate the total value for the three main safety culture dimensions.

Table 4.18 Results of total value of three dimensions

	Main Criteria		
Dimension	**Psychological**	**Situational**	**Behavioural**
Psychological	1.000	0.678	0.467
Situational	1.476	1.000	0.699
Behavioural	2.141	1.431	1.000
SUM	**4.617**	**3.109**	**2.166**

(c) Calculate the Normalised Main Criteria by dividing the value of Psychology in (b) with the sum. For example, 1.000/ 4.617 to obtain Normalised Score for Psychology = 0.217 as seen in the table below. Priority Vector or Weightage was calculated by taking the average for each row each of Psychological, Situational, and Behavioural, and the percentage was calculated.

Table 4.19 Results of Normalised Main Criteria

Normalised Main Criteria					
Main Criteria	**Normalised Score Psychological**	**Normalised Score Situational**	**Normalised Score Behavioural**	**Normalised Principal Eigen**	
				Priority Vector @Weightage	**Percentage %**
Psychological	0.217	0.218	0.216	0.217	21.67
Situational	0.320	0.322	0.323	0.321	32.13
Behavioural	0.464	0.460	0.462	0.462	46.19
SUM	1.000	1.000	1.000	1.000	100

(d) To check the consistency, for example, for psychological, the value of 0.217 in (d) was divided by the sum of psychological from (a) (e.g.: 0.217/4.617 = 1.001 in the table below). For λ_{max} = 3.000 was obtained by adding all the values in a row.

Table 4.20 Results for Consistency Index

Check for Consistency			
Psychological	**Situational**	**Behavioural**	**λmax**
1.001	0.999	1.000	**3.000**

(e) For Consistency Ratio, CR = CI/ RI.

Table 4.21 Results for Consistency Ratio (CR)

CI calculation	**CR calculation**
CI = $(\lambda_{max}$-n) / (n-1) = (3-3)/(3-1) = 0	Consistency Ratio = CI/RI Where RI is Random Index For n= 3, RI is 0.58, Therefore, CR= 0/ 0.58 = 0.00

For the main criteria of safety culture, it was totally accepted since CR <0.1 or 10%, as shown in Table 4.22. All these steps were repeated for all sub-criteria for Psychological, Situational, and Behavioural dimension (24 total sub-criteria). Results of

Consistency Ratio (CR values) for the main criteria and sub-criteria are summarised in Table 4.22.

Table 4.22 Overall Results of Consistency Ratio (CR value)

Item	**No of Matrices (n)**	**Consistency Ratio (CR)**	**Remarks**
Main criteria	3	0.000	Accepted (CR<0.1)
Sub-criteria for Psychological	5	0.059	Accepted (CR<0.1)
Sub-criteria for Situational	9	0.133	Accepted with strong justification even though (CR> 0.1)
Sub-criteria for Behavioural	10	0.136	Accepted with strong justification even though (CR> 0.1)

The values of the Consistency Ratio (CR) for Situational and Behavioural obtained were 0.133 and 0.136, respectively. Both were accepted according to previous scholars, even though the values of the CRs were slightly bigger than 0.1. CR depends mainly on the matrix size, following the recommendations of Wedley (1993). In addition, it depends on the sample characteristics and the analysis (group and/or individual). For individual experts, CR was restricted to 0.10 or 0.15, while for group responses CR could be relaxed to 0.20 to allow for non-expert responses following the recommendations by Ho, Newell, and Walker (2005). In this case, the situational and behavioural were considered big matrices with *10 x 10* and *9 x 9* matrices, respectively. Moreover, the allowable CRs for both cases (0.133 and 0.136) were within the range of 0.10 to 0.15 (Ho et al., 2005). Therefore, both CRs were accepted. Furthermore, Table 4.23 shows the summary of AHP results for local and global weights. The details of the calculation on the AHP are available in supporting documents.

Table 4.23 Rank of Main criteria and sub-criteria

Main criteria (Local weight)	Weight of Main Criteria (Rank)	Sub-main criteria	Symbol	Local Weight	Global Weight	Overall Rank based on Global Weight
Behavioural	0.46 (1)	1. Management action and responsibility	MA	0.101	0.047	6
		2. Safety communication	SC	0.054	0.025	13
		3. Leadership	LE	0.179	0.083	2
		4. Safety training	TR	0.103	0.047	6
		5. Safety awareness	AW	0.148	0.068	4
		6. Safety reporting	RE	0.063	0.029	12
		7. Safety promotion	SP	0.095	0.044	7
		8. Enforcement on safety rules	EN	0.150	0.069	3
		9. Reward and punishment	RP	0.107	0.049	5
Situational	0.32(2)	1. Safety policy	PO	0.071	0.023	15
		2. Safety audit	AU	0.123	0.039	9
		3. Safety rules	SR	0.090	0.029	12
		4. Competent SHO	SO	0.073	0.024	14
		5. Safety education	SE	0.114	0.037	10
		6.Safety programme	PR	0.115	0.037	10
		7. Safety planning	PL	0.102	0.033	11
		8. Medical surveillance	MS	0.130	0.042	8
		9. Safety competency	CO	0.115	0.037	10
		10. Safety signage	SS	0.067	0.021	16
Psychological	0.23 (3)	1. Management care on workers	MC	0.196	0.042	8
		2. Safety attitude	SA	0.437	0.095	1
		3. Job satisfaction	JS	0.093	0.020	17
		4. Health of worker	HW	0.203	0.044	7
		5. Peer influence	PI	0.071	0.015	18

4.4.5 Discussion on Prioritised Factors of Safety Culture

The ranking of main factors and sub-factors is shown in Table 4.23. The main factors were ranked in descending order, and it shows that the most prioritised safety culture factor in the Malaysian mining industry with respect to the weight of the main criteria were behaviour dimension (0.46), followed by situational (0.32), and psychological (0.22). The sub-factors global weights were also ranked, and the top-five sub-factors were further discussed. Table 4.23 shows Safety Attitude (0.905) as the prioritised risk, followed by Leadership (0.083), Enforcement of safety rules (0.069), Safety awareness (0.068), and Reward and punishment (0.049).

The factor of safety attitude among mine workers was agreed upon by the respondents as the most prioritised factor that influenced the formation of safety culture. Many previous scholars have highlighted the importance of positive safety attitudes to form a safety culture at the workplace. For example, in Sweden, the safety attitude was reported by Lööw et al. (2019). He analysed the safety-related developments in the Swedish mining industry over a 30-year period, from the 1980s to the 2010s. One of the difficulties in implementing a safety culture was due to ignorance about safety among miners (Lööw et al., 2019). Wu et al. (2017) also investigated 725 coal miners and concluded that 84% of the miners have a low educational background, which leads to a fatalist attitude and low self-motivation among miners.

The second-highest influencing factor was the leadership factor, which falls under the behavioural dimension. One of the main factors highlighted by many scholars was the leadership of top management, as well as the supervisor at the site to ensure the safety culture could be built effectively. The weak safety culture could lead to mining disasters (Jiang et al. 2020). The most common lack of leadership including inadequate supervision, an inappropriate operation plan, unresolved problems, and violations of supervisor duties, are the common issues of poor supervisor leadership, poor communication and coordination, and improper safety measures that led to incorrect decisions by the supervisor (Liu et al. 2018; Aliabadi et al. 2018; Pons, 2016). In the Malaysian scenario, the Delphi experts, such as R2, highlighted the importance of top management appointing the correct candidate to hold a position as the Safety Manager and Safety Officer, which can help strategise the safety planning for the whole mining company. The appointed person must have extensive experience in mining operations and understand the nature of mining industry. The failure to appoint the correct candidate was an example of poor safety organisation structure and inefficient safety management in the mining industry (Li et al. 2019; Xiang et al. 2019).

Enforcement on safety rules that fall under the behavioural dimension is ranked as the third most prioritised factor in establishing a safety culture in the Malaysian mining industry. Previous scholars have highlighted many challenges that mine owners face after mining accidents such as;

i. To improve the supervision systems of mining companies (Chen, Xu, and Fan, 2015).
ii. To participate in any mine accident investigation (Chen et al. 2015).
iii. To ensure all safety flaws can be prevented and eliminated at regulatory and technical levels (Chen et al. 2015).
iv. To prevent a culture of corruption, which is a root cause of major coal mine accidents (Geng and Saleh, 2015).
v. To create a healthy relationship between managers and employees (Chen et al., 2015).
vi. To change the attitude of coal miners from inactive to active mode, and to ensure unreported dangers can be minimized (Wang et al. 2016).
vii. To enhance the risk management process and managerial integrity in handling underground coal mine accidents (Pons, 2016).
viii. To change owners' mining practises and foster a safety culture in mining companies (Pons, 2016).
ix. To ensure all staff and mine workers follow the safety culture in their normal daily practises at work (Düzgün and Leveson, 2018).
x. To increase safety commitment, ensure good communication with miners and colleagues (Li et al. 2019).
xi. To provide sufficient safety equipment and improve the safety behaviour of miners and mine owners (Li et al. 2019).
xii. To provide a good working procedures and training programmes to reduce the possibility of workplace accidents (Aliabadi et al. 2019).
xiii. To ensure staff prevent any possibility of harmful or dangerous incidents, or exposure to heavy metals or toxic chemicals (Lyra, 2019).

Therefore, to prevent mining accidents or disasters, many researchers have highlighted the importance of safety culture in minimising those accidents (Jiang et al., 2020). One of the efforts was the enforcement of safety rules (Lyra, 2019). Incomplete or poor execution of rules and regulations and poor rules and regulations are examples of poor enforcement of safety rules (Gui et al. 2019). The enforcement of safety rules at the mine site could save the lives of workers and prevent any major mining accidents.

Safety awareness is ranked as the fourth prioritised influencing factor to establish a safety culture, as agreed by the respondents. Safety awareness can be raised in a short period of time. The top management must actively promote safety at the workplace by organising safety activities such as seminars, safety weeks, and safety talks. Poor safety awareness could lead to mining disasters or accidents (Li et al. 2019). According to Wang et al. (2018), by having a good operating plan to ensure safety awareness is applicable throughout all mining operations. Moreover, he added that by enhancing safety awareness among employees and top management, the safety culture can be built more effectively (Wang et al., 2018).

Reward and punishment are ranked as the fifth prioritised influencing factor to establish a safety culture in the Malaysian mining industry. The unsupportive environment in the mining industry should be overcome because it can also contribute to job dissatisfaction and have a bad impact on the mine workers' productivity. The tendency for safety rule breaches among miners, such as imperfect emergency management systems, failure to follow safety production systems, unauthorised risk-taking operations, and use of equipment, occurred (Zhang, et al. 2020). Moreover, the ignorance of safety rules was due to a lack of knowledge about safety itself, which will lead to mining disasters (Zhang et al. 2020). Therefore, one solution was to give awards and appreciation to excellent miners to motivate them in the safety context (Wang et al. 2018).

4.4.6 Concluding remarks of AHP

The prioritised influencing factors of safety culture were successfully identified by using the AHP method. The top-five influencing factors were Safety Attitude (0.905) as the prioritised risk, followed by Leadership (0.083), Enforcement of safety rules (0.069), Safety awareness (0.068), and Reward and punishment (0.049). To validate these findings, the researcher conducted (i) a focus group discussion (FGD) and (ii) a case study at a volunteer mining company in Pahang.

4.5 Results on Focus Group Discussion: Validation of Safety Culture Framework

4.5.1 Validity and Reliability

This research must meet two essential requirements in order to produce high-quality findings: validity and reliability (Saunders et al. 2016). Validity is a procedure that entails evaluating our research data and the overall explanation (Yin, 2018). Reliability is used to evaluate the consistency of our findings and the quality of our research in order to reduce errors and show that the research can be repeated with the same outcomes.

There are two methods for assessing the validity of our research (Saunders et al., 2016);

i. Triangulation, which means the use of several sources of data to confirm the validity of the research.
ii. Participant or member validation means the data are sent to the participants to confirm the accuracy of the results and if the results are valid for use.

The researcher chose to employ participant or member validation to validate the qualitative research, which entails sending the data to the participants to ensure the results are accurate and may be used (Sanders et al. 2016). The Focus Group Discussion was created in this instance to confirm the results. Additionally, it was to assure the accuracy of all results obtained from the preceding Delphi I, Delphi II, and AHP results, as well as their validity. Meanwhile, for reliability, the case study was conducted at a volunteer mining company, which was further discussed in Section 4.6. Figure 4.15 shows the source of evidence to validate the safety culture research study by using the FGD method.

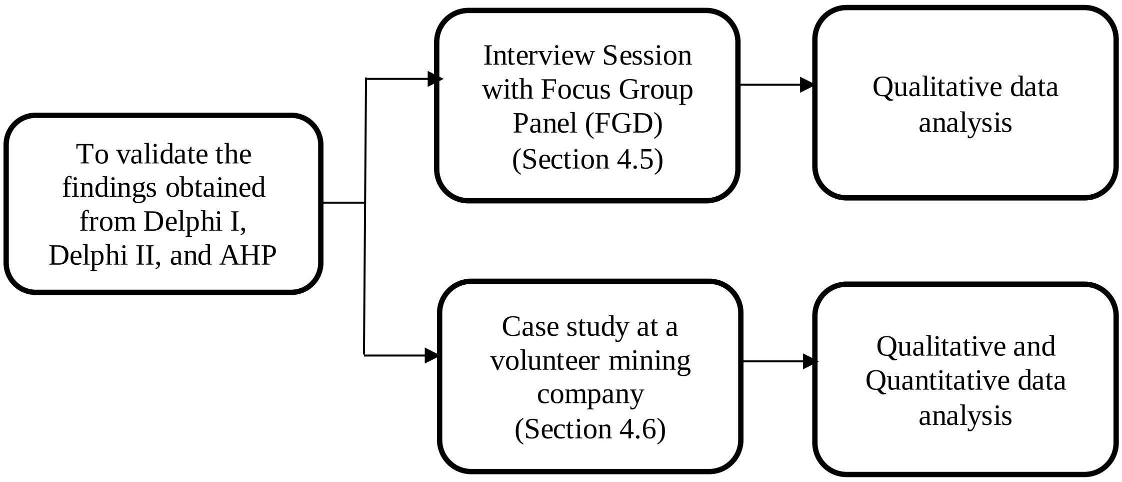


Figure 4.16 The source of evidence to validate safety culture research study

4.5.2 Validation for Qualitative Findings by conducting a Focus Group Discussion

The FGD sessions successfully gathered five (5) panels to discuss in detail the influencing factors of the safety culture framework for the Malaysian mining industry and to validate the previous findings. The examples of the email invitation and official appointment letters for FGD panels are appended in Appendices V and W, respectively. The number of panels also followed the suggestion by Nyumba et al. (2018), which is that the FGD should consist of 4 to 15 panels only. FGD was conducted via Google Meet platform on January 13, 2022. The session started with a short briefing chaired by the researcher on the main objective of the focus group discussion (FGD) and the flow of the FGD session. Then, it was followed by a self-introduction session by each of the panel experts. The session was recorded and took around 1 hour and 30 minutes. Table 4.24 shows the background of the FGD panels.

Table 4.24 Background of the FGD panels

Panel Expert	Position	Locality	Working Experience (years)	Expertise
E1.	Acting Manager-Mine Geology Dept.	Pahang	25	Mineral Development Mine Operation
E2.	Coal mining consultant	Sarawak	20	Mine Operation Mine Safety
E3.	Occupational Safety, Health, and Environment (OSHE) Training Consultant	Sarawak	17	Mine Operation, Mine Safety
E4.	Senior Geologist	Sabah	15	Mine Development Mine Business Mine Safety
E5.	Safety Health Officer	Sarawak	15	Mine Operation, Mine Safety

4.5.3 Validation and Discussion on Psychological Dimension

The researcher showed the list of influencing factors on psychological safety culture as results of Delphi I and II findings. The definition of each factor is shown in Table 4.25. The researcher asked the question, "*How much do you agree or disagree with the influencing factors of situational safety culture found in this study?*" and each expert was given ample time to air their point of view on each factor and definition.

The experts (EI) agreed with the list of factors and raised their concern, as stated;

> *"I agree with all the factors but the problem here is how we can synchronize all these things. Even though we have a good law (rules and regulations), the main problem is the safety attitude. If we want to achieve a good safety culture, we need to change their (mine worker) attitude first".*

Meanwhile, Expert (E2) agreed with E1 that safety attitude is important to form a safety culture. He also agreed with the list of psychological factors stated in Table 4.25. This finding showed that safety attitudes are crucial to constructing safety culture in the mining industry. Jiang et al., (2019) revealed that poor physiological status and bad safety habits are examples of safety attitudes that contribute to mining accidents among 27 coal mines in China. Moreover, the ignorance of safety among miners is also an example of a bad safety attitude (Lööw and Nygren, 2019).

Table 4.25 The validated definition of each factor for psychological dimension

Psychological Dimension		
No.	**Factors**	**Definition**
1.	Management Care for Workers	Refers to management's interest with workers' psychological conditions as they relate to their work environment and performance.
2.	Safety Attitude	Refers to mine workers' psychological attitudes regarding workplace safety culture, procedures, and accident prevention.
3.	Job Satisfaction	Refers to a worker's satisfaction with the task he or she has been assigned without undermining the employer's efforts.
4.	Health of Workers	Refers to a worker's physical and mental ability to do the task at hand.
5.	Peer Influence	Refers to co-workers or colleagues who have a significant impact (good or bad) on the development of a workplace safety culture.

4.5.4 Validation and Discussion on Situational Dimension

The session continued by asking the experts for their comments and points of view on the factors of Situational dimension to build a safety culture framework in the Malaysian mining industry. The definition of each factor for the Situational dimension is shown in Table 4.26. At this stage, the researcher asked the question, "*How much do you agree or disagree with the influencing factors of situational safety culture found in this study?*"

Table 4.26 The validated definition of each factor for Situational Dimension

Situational Dimension		
No.	**Factors**	**Definition**
1.	Safety Policy	Refers to the mining companies stated OH&S policy and OH&S objectives, which include compliance with OSH legal requirements and other government-imposed requirements.
2.	Safety Audit	Refers to the auditor's internal and external audits and ensures that all records are appropriately documented for future reference.
3.	Safety Rule	Refers to all of the mining company's developed standard operating procedures, guidelines, rules, regulations, and safety practises, which must be followed by all mine personnel and do not conflict with local authorities' and government's requirements.
4.	Competent SHO	SHO is well-trained and experienced in mining operations and activities, and referred to as a competent SHO.
5.	Safety Education	Refers to any type of education and training offered by management to improve employees' safety skills, knowledge, and competency.
6.	Safety Programme	Refers to current and completed programmes, events, and activities such as safety awareness week, safety first, and others.
7.	Safety Planning	Refer to all short- and long-term plans, as well as ongoing safety planning offered to employees by senior management. For future reference, everything forthcoming and completed planning must be carefully documented.
8.	Medical Surveillance	Top management assigns an Occupational Health Doctor to evaluate employee health and safety to ensure that employees are physically and psychologically capable of doing their duties.
9.	Safety Competency	Refers to employees' prior safety knowledge and work experience, as well as any ongoing safety training or education they get to improve their professional abilities and competences.
10.	Safety Signage	Refers to any chemical signage, working station signage, mining site signage, or safety promotion signage that is used to keep personnel informed of impending dangers.

According to Table 4.26, a coal mining consultant (E2) with 25 years of mining experience agreed with the list of influencing factors of safety culture and their respective definitions obtained by the researcher. He mentioned;

> *"We look at safety policy. It must start by the authority and at this stage all the mine owners must follow and have safety policy for their company. For situational dimension, I agreed this is very important. If we have a strict safety policy, all the miners will follow it because they must abide*

the rules as stated in the contract. If the accidents occur, we will close their mine."

Moreover, E1 panels agreed with all the factors, as shown in Table 4.26. He also highlighted several important factors, such as the importance of safety policies, enforcement of safety rules, safety training, and safety attitudes, as mentioned below;

> *"Actually Mrs. Siti (researcher), we are a bit slow (safety culture) in mining because Malaysia is a small country. I think we are not up to 5% (mining) of our country. Even Act of Mine in Malaysia we still use what the UK has until now. Then, other factors, resources model, all of that there is no form of control, so we depend a lot on many foreign countries compared to China, they have very great mining. In Malaysia, for example, we have more than 20 gold mines, however in Indonesia there are almost 1000 gold mines, so if they don't take care of these 1000 mines, their mining industry (Indonesia) will be destroyed. I want to add a little more, the most important thing that is the opposition about this (safety culture). Safety culture is a safe work culture. If you want it as a culture, it must be something that is not made up, it needs to be automatic, to get to the automatic level and become that culture, that's the hard part. The challenge is to ensure the safety run continuously. It's not 1 month for safety activities, the next month we forget. Just like the 5S file, we make it 3 months later and forget it and go back to the way it was and it still hasn't become a culture. Similarly, mere training has not yet become a culture. For example, safety attitude, enforcement all need to be combined so that it becomes a culture and needs to continue so as not to forget (remind continuously)".*

4.5.5 Validation and Discussion on the Behavioural Dimension

The session continued by asking all the experts "How much do you agree or disagree with the influencing factors of behavioural safety culture found in this study?" According to OSHE Trainer with 20 years of experience, she agreed with the list of factors stated in Table 4.27. She also added;

> *"Main problem for top management is they have business background and business minded and mostly they have purely business knowledge and not concern about safety. They lack of safety knowledge and safety awareness. Their knowledge only how to make money, make profit. So, if the top management do not commit with safety concerns, there*

is no safety awareness exists. So, safety awareness must come from top management and later he will commit on safety issues".

Table 4.27 The validated definition of each factor for behavioural dimension

Behavioural Dimension		
No.	**Factors**	**Definition**
1.	Management action and responsibility	Refer to top management's commitment to ensuring that all employees follow the company's safety policies and rules.
2.	Safety communication	Refer to management's communication channels, such as email, memos, safety briefings, bulletin boards, and reporting systems to guarantee dual communication between employees and employers.
3.	Leadership	Refer to a well-trained and experienced SHO, supervisor who is capable of effectively leading and supervising personnel.
4.	Safety training	Refers to management's commitment to offer staff sufficient training and competence courses.
5.	Safety awareness	Refers to employee knowledge of the significance of safety and the culture of safety at work, as well as comprehension of safety policies. Standard Operating Procedures (SOPs), standards, and regulations
6.	Safety reporting	To report misbehaviour or unethical concerns involving workers or supervisors, use the management-provided method, which may be used either offline (manually) or online.
7.	Safety promotion	Any promotion, including activities and programmes created by management to instil a safety culture at work, such as safety weeks, safety films, safety signs, safety talks, and safety seminars.
8.	Enforcement on safety rules	Refer to the established SOP, regulations, and standards, which must be adhered to by all levels of personnel.
9.	Reward and punishment	Refer to bonuses to reward excellent employees, or any misbehaviour or unethical behaviour by employees must be penalised.

Moreover, a Senior Geologist with 20 years of experience agreed with these factors, and he added that the leadership of the mine owner, management commitment, and safety budget are important to form a safety culture at a mining company. He gave an example as follows;

"Just to add on, my opinion in cultivating safety culture in the workplace is like building a government. A government is advanced and prosperous when it goes through a phase

> *of wealth, calm and no problems/turmoil/war. This example applies to a (mining) company. Although the leader of the government needs to complete all the needs of the government/policy/safety etc. but he needs to stabilize the government's economy/income first and practice or use a small budget for the government's safety. So, between big companies and small (mining) companies they need to go through a phase of stability, calmness before they can think about other issues including safety and others and then become their work culture or practice. After the government (mining company) is stable, then psychological, situational, and behavioural factors develop into practices and culture. Indirectly, the public or employees (mine workers) will feel that safety, health and security are very important to them and they want to be an example to the government (company) or other (mining) companies.*

4.5.6 FGD's Views on AHP Results

All FGD panels agreed with the findings of AHP, which stated the top five prioritised factors of safety culture were (1) Safety attitude, (2) Leadership, (3) Enforcement of safety rules, (4) Safety awareness, and (5) Reward and punishment, as shown previously in Table 4.23. Based on the findings of the OSHE Training Consultant (E3), she agreed that safety attitude was the main factor. She said;

> *"Safety attitude among mine workers are still low and need to be improved. They prefer short cut method, still break the rules". She added; "Leadership of mine owner is very important to give clear direction on the safety at workplace. I also agreed the enforcement; safety awareness must be done to build safety culture."*

The top five prioritised factors were also agreed by the Acting Manager (E1) who claimed;

"I can see the mining problem (to create safety culture) is safety attitude of mine workers itself. The leadership of top management is important, as well as the safety awareness. Reward and punishment also helps to create a safety culture at mining industry"

4.5.7 Concluding Remarks for FGD

The Focus Group Discussion (FGD) was successfully conducted with a great input and constructive discussion from all the experts, as well as the validation process on the proposed safety culture framework. They hope this research can contribute to the mining industry in Malaysia, especially for mine operators and mine workers, by increasing awareness of the importance of safety culture at mine sites and reducing mining accidents in this country. To conclude, they also agreed and validated all the factors, and each definition reflected the establishment of a safety culture framework for the Malaysian mining industry that inclusively touched on psychological, situational, and behavioural dimensions.

4.6 Results and Discussion on Case Study at a Volunteered Mining Company

As discussed in Section 4.5, the validation was conducted by a Focus Group Discussion (FGD). The next step was to validate the findings by conducting a case study at a volunteer mining company in Pahang, Malaysia. An email requesting permission to conduct a research study at a mining company, and the letter of approval was appended in Appendices X and Y, respectively.

4.6.1 Reliability

According to Yin (2018), there are six sources of evidence in case studies: (i) documentation, (ii) archival records, (iii) interviews, (iv) direct observations, (v) participant observation, and (vi) physical artefacts. The main objectives of reliability are to check the consistency of our findings and the quality of our research to minimise errors and demonstrate that the research can be repeated with the same results.

To ensure the reliability of this research, the researcher linked the theoretical part to the empirical data to validate the influencing factors of the safety culture study at a mining company, which is based on three sources of evidence or triangulation: (i) real life observation at the mine site, (ii) the documentation (Safety Culture Assessment Questionnaire) for both the manager and mine workers, and (iii) interviews with the top management of mining company X, as shown in Figure 4.16.

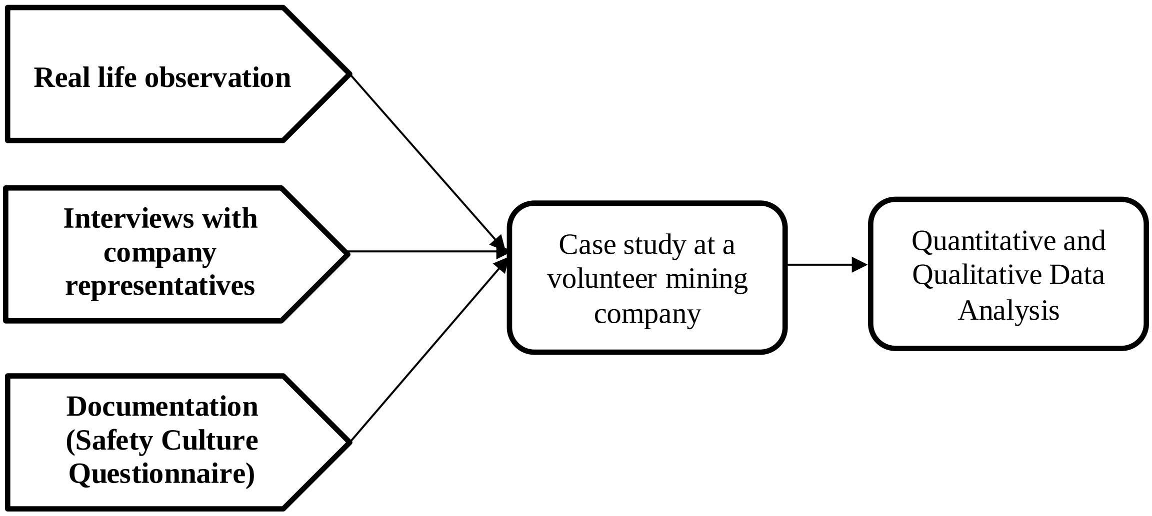


Figure 4.17 Three main sources of the safety culture research study at mining company X

4.6.2 Pre- and post-observations at the mine site

The case study was conducted at a volunteer mining company in Pahang for three months. Due to limitations on access to the mining site, the company gave permission to include the excavation site and mineral processing area only for observation purposes for the safety culture study. The observation was conducted in two different ways. First observation consists of pre- and post-observations. Pre-observation was done for one week during eight working hours for mine workers at the excavation and mineral processing areas. The post-observation was conducted after some recommendations to the mining company were made for improvement. An example of pre- and post-observations was illustrated in Table 4.28.

Table 4.28 Example of results from real life pre- and post-observations on mine workers

Observation area	Pre-observation findings	Recommendations to mining company	Post-observation findings
Excavation site	Some foreign workers did not wear safety shoes and safety helmets.	Enforcement on wearing proper PPE	Some foreign workers wore safety shoes and some of them were still reluctant due to hot weather and working conditions
Mineral X processing area	Some foreign workers did not wear safety shoes and safety helmets and some of them also did not wear ear plugs to prevent noise hazards at the processing area.	Enforcement on wearing proper PPE	Some foreign workers wore safety shoes and some of them were still reluctant due to hot weather and working conditions.

The second observation was followed by the Occupational Safety and Health Work Assessment (OSHWA) from the Department of Safety and Health Malaysia (DOSH), which contains two main components: (1) a physical audit and (2) a documentation audit. Most of the information was obtained directly from the Assistant Manager and Plant Manager of the mining company. The details resulting from the observation and the checklist was mapped to the respective influencing factors of safety culture were available at supporting documents.

4.6.2.1 Discussion on Pre- and Post-observations at mine site

The observation was conducted at a mine site, and the OSHWA Physics Audit checklist was used for observation purposes. According to the mapping of the Checklist of Physical Audit OSHWA for pre-observation at excavation and mineral processing areas to the respective influencing factors of safety culture, the mine owner showed his commitment by providing good physical facilities at excavation and mineral processing areas. All the working areas have clear safety signage and the chemicals used were labelled properly. The company also provides a good Safe Work Procedures (SOP), which all workers need to follow. However, there are some issues, such as the safety attitude of foreign workers from Bangladesh like their ignorance to wear safety shoes, a safety helmet, and ear plugs while handling machines at the mineral processing area. They claimed that working conditions were too hot and comfortable not to wear it. However, the suggestion has been made to the management to do safety enforcement and also penalise workers who do not follow the safety rules. This is important to avoid any injuries or mining accidents at the workplace.

4.6.3 Interview Sessions and Discussion

The interview sessions have been conducted in separate sessions for each manager on the influencing factors for constructing a safety culture at the mine site. The date of the interview with the Chairman, Managing Director, and Plant Manager is shown in Table 4.29. There are several questions that have been asked to the managers, such as;

i. *Could you please share the current safety practises of workers at your company?*
ii. *Could you please share the current safety culture level at your company?*
iii. *In your opinion, what are the main factors in creating a safety culture and their challenges at your company?*
iv. *How much do you agree or disagree with the influencing factors of psychological safety culture found in this study?*
v. *How much do you agree or disagree with the influencing factors of situational safety culture found in this study?*
vi. *How much do you agree or disagree with the influencing factors of behavioural safety culture found in this study?*

Table 4.29 Tentative Schedule of Interview Sessions at the Mining Company

Date of interview	Job Position	Duration
2 Dec 2022	Plant Manager	30 minutes
5 January 2023	Managing Director	30 minutes
3 April 2023	Chairman	30 minutes

Based on the interview sessions, the Chairman also validated the findings of the researcher. He also stated that the main problem at his company is managing the foreign workers who ignore wearing proper PPE due to the hot working conditions and feeling uncomfortable. The Managing Director and Plant Manager also agreed with the influencing factors of safety culture found by the researcher. The Plant Manager claimed that the safety culture practises at his mine site are quite good. However, there are also a few problems, such as the ignorance of some foreign workers about the safety rules. For example, some foreign workers are not wearing proper Personal Protective Equipment (PPE), such as a safety helmet while performing the job. He already emphasised the importance of safety at the mine site, including providing safety signage at the excavation and tin processing areas.

Moreover, the company also has an allocation or budget for safety to provide good and proper PPEs to all workers. Safety training and annual a medical check-up is also provided by the company to all mine workers. He also agreed with all the influencing factors for psychological, situational, and behavioural highlighted by researchers. However, he also mentioned that he never conducts any safety culture assessment at the mine site and welcomes the researcher to conduct it at his mine site. To conclude, the three top managers agreed and validated the influencing factors of safety culture found by the researcher and very significant in the mining industry.

4.6.4 Documentation on Safety Culture Assessment

According to the Plant Manager, he mentioned that the company has not conducted any safety culture assessments before. Therefore, they do not have any evidence on safety culture awareness or practises for the company. However, he mentioned they followed all the rules, regulations, and checklists as enforced by the Department of Safety and Health Malaysia (DOSH) and the Mineral of Geoscience Department (JMG). According to DOSH, OSHWA is a self-regulated assessment for mine owners to evaluate their safety and health at the mine workplace. In general, OSHWA consists of two parts; Physical Audit and Documentation Audit. Overall, based on the checklist of OSHWA audits for physical and documentation audits, the Plant Manager mentioned that the mining company managed to get a Grade B for the overall OSHWA assessment in year 2021, which is equivalent to 70% to 75% marks. This shows the company has quite good safety practises and obeys most of the rules highlighted by DOSH.

For this subsection, using OSHWA Documentation Audit, the researcher conducted a simple documentation audit for mining company X with the assistance of the Assistant Manager. Since the Plant Manager mentioned that the company has not conducted any assessment focusing on influencing factors of safety culture, it is a good opportunity for the researcher to conduct a safety culture questionnaire survey as discussed in Section 4.6.5 The results of the documentation audit for excavation and mineral processing areas only by using the OSHWA checklist were mapped to the respective influencing factors of safety culture were available at supporting documents.

According to Plant Manager, he claimed they never conducted any safety culture assessment, therefore he welcomed researchers to conduct safety culture assessments at the mining site, as discussed in Section 4.6.5, by distributing a questionnaire survey to workers and mine owners

4.6.5 Analysis and Discussion on Questionnaire Survey at a Volunteer Mining Company

A questionnaire survey at a volunteered mining company was conducted since there is no empirical evidence on safety culture studies at mining companies. The questionnaire survey was conducted to investigate the managers and workers' perceptions of safety culture practises at the mine site. Due to limitations and restrictions access by the mine owner, the number of respondents for the questionnaire survey is minimal.

The questionnaire was divided into two parts. One set of questionnaires was distributed to the top management (Chairman, Managing Director, Plant Manager), and another set was distributed to the management level (Finance Manager, Assistant Manager) and mine workers at the excavation and mineral processing area (two supervisors and five workers). By using 5 points of Likert's scale with one being 'strongly disagree' and five being 'strongly agree', a questionnaire survey was used. The questionnaire used for the mining company was a similar set of questionnaires used in Delphi II previously with slight changes in sentences, as shown in Table 4.30. The background of the respondents at the mining company X is as shown in Table 4.31.

Table 4.30 An example of the questionnaire sent to mining company

From Delphi II ***(Questions were previously validated by Validator)***	**For Managers at mining company X**	**For workers at mining company X**
The established OH&S policy and OH&S objectives of the mining company are compliant to OSH legal requirements and other requirements set up by the government.	I established OH&S policy and OH&S objectives for my mining company and comply with OSH legal requirements and other requirements set up by the government.	My managers established OH&S policy and OH&S objectives of my mining company and comply with OSH legal requirements and other requirements set up by the government.

Table 4.31 Background of respondents at mining company X

Job Position	**Years of experience in mining industry**	**Area of case study**	**Nationality**
Chairman	13	Give permission to access excavation and mineral processing area only	Malaysia
Managing Director	20		Malaysia
Plant Manager	10		Malaysia
Finance Manager	8		Malaysia
Assistant Manager	3		Malaysia

Table 4.31 Continued

Job Position	Years of experience in mining industry	Area of case study	Nationality
Supervisor	10	Excavation area	Malaysia
Supervisor	7	Mineral processing area	Malaysia
Mine Worker	7	Excavation area	Bangladesh
Mine Worker	7	Excavation area	Bangladesh
Mine Worker	7	Mineral processing area	Bangladesh
Mine Worker	7	Mineral processing area	Bangladesh
Mine Worker	7	Mineral processing area	Bangladesh

4.6.5.1 Analysis and Discussion on Psychological Dimension at a Volunteer Mining Company

The questionnaire survey of the psychological part consists of five main sub-factors for managers and workers' perceptions. By using 5 points of Likert's scale, with one being 'strongly disagree' and five being 'strongly agree', the results and individual ratings for the Psychological dimension are shown in Table 4.32.

Table 4.32 Questionnaire survey results for Manager's and Worker's Perceptions on Psychological Dimension

Psychological Dimension										
Factors	No.	Question	Managers' Self-Evaluation				Workers Evaluating Managers			
			Median	Mean	SD	IQD	Median	Mean	SD	IQD
1. Management care on workers	1(i)	[I / My manager]* able(s) to identify and recognize the workers that work under pressure and have intention to take shortcuts about safety.	4.00	4.00	1.00	1.00	5.00	4.89	0.33	0.00
	1(ii)	[I / My manager*] concern(s) on mine workers involved in mining accidents or any injuries.	5.00	4.67	0.58	0.50	5.00	4.78	0.44	0.00
	1(iii)	[I / My manager*] alert on worker's ability to identify the potential hazard and risk while handling machinery or performing the given task	4.00	4.33	0.58	0.50	4.00	3.89	1.05	2.00

Table 4.32 Continued

Factors	No.	Question	Managers' Self-Evaluation Median	Managers' Self-Evaluation Mean	Managers' Self-Evaluation SD	Managers' Self-Evaluation IQD	Workers Evaluating Managers Median	Workers Evaluating Managers Mean	Workers Evaluating Managers SD	Workers Evaluating Managers IQD
		Psychological Dimension								
	1(iv)	[I / My manager*] concern on the workers that affects or can affect the Occupational Health and Safety (OH&S) performance of company.	4.00	4.33	0.58	0.50	4.00	4.11	0.93	2.00
	1(v)	[I / My manager*] listen (s) and give attention (s) to my worker's opinion for improving work safety	4.00	4.33	0.58	0.50	5.00	4.22	0.97	2.00
	1(vi)	[I / My manager*] believe safety is of paramount importance.	5.00	5.00	0.00	0.00	5.00	4.22	0.97	2.00
2. Safety Attitude	2(i)	[I / My manager*] feel(s) free to report safety violations at my company	4.00	4.33	0.58	0.50	4.00	4.00	0.87	2.00
	2(ii)	[I / My manager*] believe (s) safety is more of a priority than finishing tasks	4.00	4.33	0.58	0.50	5.00	4.33	1.00	2.00
	2(iii)	[I / My manager*] care (s) more about safety than the workers	4.00	4.00	0.00	0.00	4.00	3.56	0.53	1.00
	2(iv)	[I / My manager*] do not tolerate any unsafe behaviours of mine workers on the job site.	5.00	4.67	0.58	0.50	4.00	4.22	0.44	0.00
3. Job satisfaction	3(i)	[I / My manager*] believe (s) job satisfaction of mine workers is more of a priority than finishing tasks	5.00	4.67	0.58	0.50	4.00	4.44	0.53	1.00
4. Health of worker	4(i)	[I / My manager*] concern (s) and care on worker's health issue including mental health issue	4.00	4.33	0.58	0.50	4.00	4.00	1.12	2.00
5. Peer influence	5(i)	[I / My manager*] believe (s) the workers point out each other's deficiencies in a work safety	4.00	4.00	1.00	1.00	4.00	4.22	0.44	0.00
	5(ii)	[I / My manager*] alert(s) my colleagues who act contrary to work safety rules.	4.00	4.33	0.58	0.50	4.00	4.22	0.67	1.00

Based on Table 4.32, it shows means and standard deviations, with a decrease in standard deviations between rounds indicating an increase in agreement on the statement (Rayens and Hahn, 2000) for both managers' self-evaluation and workers' evaluation of managers. In addition, according to the interquartile deviation (IQD), the level of consensus on the statement also showed both managers and workers agreed on the statement for each row. Consensus is achieved if an IQD of 1.00 or less is obtained (Spinelli, 1983). Based on the table, managers claimed they were concerned about psychological factors in health issues with IQD = 0.50 and achieved agreement. However, when the workers evaluated their managers, the IQD result of 2.0 indicated disagreement with the statement. However, based on Lamers et al. (2016), the level of consensus for 5 points Likert's scale can be analysed based on the median as categorised: (i) Median >3: consensus on agreement with a statement, (ii) Median = 3: no consensus on agreement with a statement, and (iii) Median < 3: consensus on disagreement with a statement. Since both resulted in Median = 4, therefore it can be considered that the agreement for both statements is achieved.

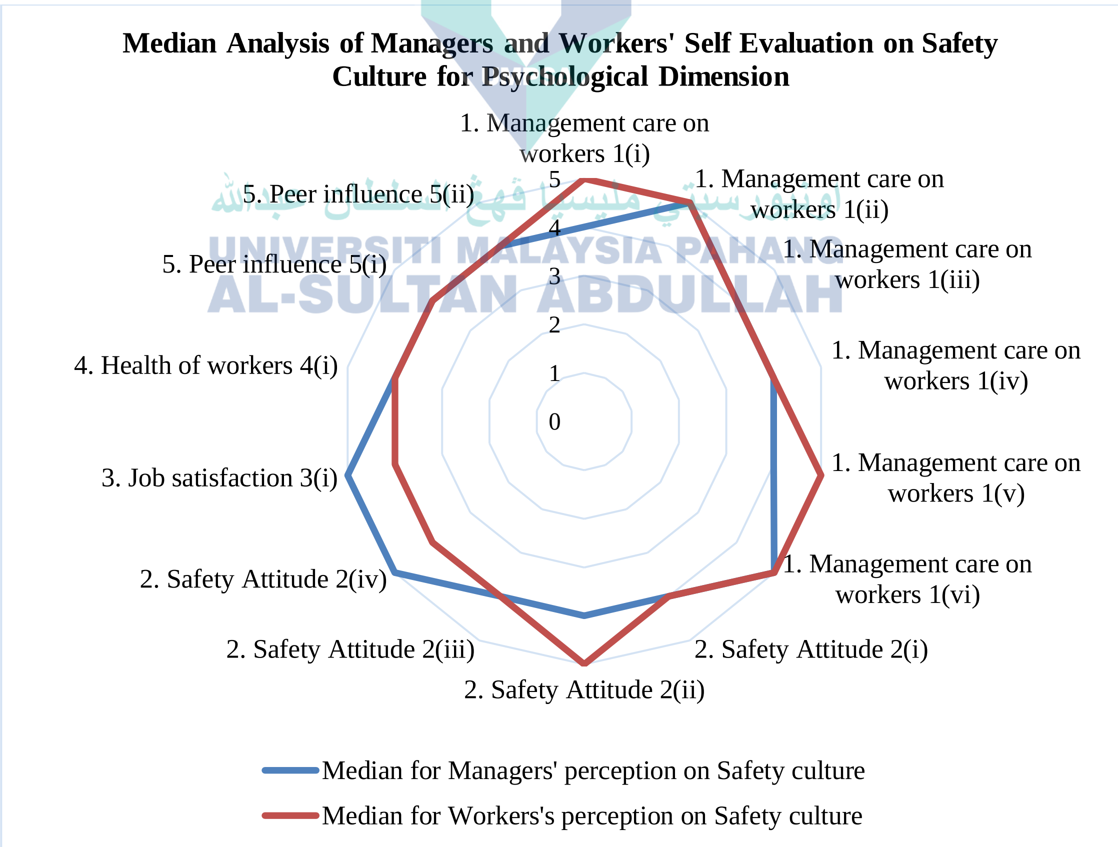


Figure 4.18 Median analysis for managers and workers' perceptions on Psychological dimension

Moreover, based on Figure 4.17, the median analysis shows the managers and workers' perceptions of Psychological dimensions at their workplace. Overall, both managers' self-evaluation and workers' evaluations of managers achieve a high level of consensus on the safety culture at their workplace since the median was bigger than 3, which means the consensus on agreement with a statement has been achieved. To conclude, the agreement was achieved because, according to Rayens and Hahn (2000), the consensus achieved is more than 60% consensus or agreement.

4.6.5.2 Analysis and Discussion on Situational Dimension at a Volunteer Mining Company

The situational part of the questionnaire consists ten main sub-factors for Managers and Workers' Perceptions. By using 5 points of Likert's scale, with one being 'strongly disagree' and five being 'strongly agree', the results and individual ratings for the Situational dimension are shown in Table 4.33.

Table 4.33 Questionnaire survey results for Managers and Workers' Perceptions on Situational Dimension

Situational Dimension										
Factors	**No.**	**Question**	**Manager' Self-Evaluation**				**Workers Evaluating Managers**			
			Median	**Mean**	**SD**	**IQD**	**Median**	**Mean**	**SD**	**IQD**
1. Safety Policy	1(i)	[I / My manager*] established OH&S policy and OH&S objectives of the mining company is compliance with OSH legal requirement and others requirement set up by government.	4.00	4.33	0.58	0.50	4.00	4.11	0.93	2.00
	1(ii)	[I / My manager*] understand (s) and comply (ies) with the relevant OH&S policies/procedures, legal requirement and other requirement of company while performing my job	4.00	4.33	0.58	0.50	4.00	4.44	0.53	1.00
2. Safety Audit	2(i)	[I / My manager*] make sure all the requirements and outcomes of OH&S management system including the OH&S policy and OH&S objectives of company will undergo an internal audit.	4.00	4.00	0.00	0.00	4.00	4.44	0.53	1.00

Table 4.33 Continued

Factors	No.	Question	Manager' Self-Evaluation				Workers Evaluating Managers			
			Median	**Mean**	**SD**	**IQD**	**Median**	**Mean**	**SD**	**IQD**
	2(ii)	[I / My manager*] make sure (s) all the requirements and outcomes of OH&S management system including the OH&S policy and OH&S objectives of company will undergo an external audit.	4.00	4.00	0.00	0.00	4.00	4.22	0.44	0.00
	2(iii)	[I / My manager*] ensure (s) the audit results are well reported and I share it to all level of management and mine workers.	4.00	4.00	0.00	0.00	4.00	3.67	1.00	1.00
3. Safety Rules	3(i)	[I / My manager*] provide(s) a clear standard operating procedure (SOP) to workers in handling machinery and chemical.	4.00	4.00	1.00	1.00	4.00	4.44	0.53	1.00
	3(ii)	[I / My manager*] make sure (s) all mine workers to use proper and complete Personal Protective Equipment (PPE) while performing job (such as working at height, handling chemical, use machinery etc).	4.00	4.00	0.00	0.00	4.00	4.00	0.87	2.00
	3(iii)	[I / My manager*] follow (s) safety rules and practices on the job site	4.00	4.33	0.58	0.50	4.00	4.44	0.53	1.00
4. Competent SHO	4(i)	[I / My manager*] hire (s) a competent Safety Health Officer (SHO) in supporting OHS management system including OH&S policies and objectives	3.00	3.00	0.00	0.00	3.00	3.44	0.73	1.00
5. Safety Education	5(i)	[I / My manager*] provide (s) the relevant and continuous education and training on OHS legal requirement and other training related to the job scope of workers.	3.00	3.67	1.15	1.00	4.00	4.11	0.93	2.00
6. Safety programme	6(ii)	[I / My manager*] make sure all the safety programme, activities or events are intended to support the OH&S policy and OH&S objectives of the mining company	4.00	3.67	0.58	0.50	4.00	4.22	0.44	0.00

Table 4.33 Continued

Factors	No.	Question	Situational Dimension							
			Manager' Self-Evaluation				Workers Evaluating Managers			
			Median	Mean	SD	IQD	Median	Mean	SD	IQD
7. Safety planning	7(i)	[I / My manager*] will take action to address non conformities and continually improve its OH&S performance to construct safety culture	4.00	3.67	0.58	0.50	4.00	4.33	0.50	1.00
	7(ii)	[I am / My manager*] responsible (s) in identifying, solving and providing preventative action related to ergonomics problem facing by workers.	4.00	4.00	1.00	1.00	4.00	4.22	0.44	0.00
	7(iii)	[I / My manager*] implement(s) the engineering controls, re-organization of work or both at workplace.	4.00	4.33	0.58	0.50	4.00	4.33	0.50	1.00
8. Medical Surveillance	8(i)	[I / My manager*] provide (s) Occupational Health Doctor to handle health issues among worker including mental health issue.	3.00	3.00	0.00	0.00	3.00	3.67	0.87	1.00
	8(ii)	[I / My manager*] provide (s) annual medical check up to all mine workers.	4.00	4.00	1.00	1.00	5.00	4.56	0.73	1.00
9. Safety Competency	9(i)	[I am / My manager*] able(s) to recognize the unsafe behaviors of the mine workers on the job site.	4.00	4.33	0.58	0.50	4.00	4.33	0.50	1.00
	9(ii)	[I am / My manager*] able to identify safety hazards at the job sites.	4.00	4.33	0.58	0.50	5.00	4.56	0.53	1.00
	9(iii)	[I / My manager*] have sufficient mining safety knowledge.	4.00	4.00	1.00	1.00	4.00	4.44	0.53	1.00
	9(iv)	[I / My manager*] consider(s) my previous working experience to create safety culture at current workplace.	4.00	4.00	1.00	1.00	4.00	4.33	0.50	1.00
	9(v)	[I / My manager*] consider(s) my previous educational background to create safety culture at current workplace.	4.00	4.33	0.58	0.50	4.00	4.11	0.33	0.00
10. Safety Signage	10(i)	[I / My manager*] provide (s) clear and proper safety signage at mine site and working area.	4.00	4.33	0.58	0.50	5.00	4.56	0.53	1.00

Based on Table 4.33, in overall, means and standard deviations, a decrease in standard deviations between rounds indicates an increase in agreement on the statement (Rayens and Hahn, 2000) for both managers' self-evaluation and workers' evaluation of managers. According to the Interquartile (IQD), the level of consensus on statements also showed both managers and workers agreed on statements for each row. Consensus is achieved if an IQD of 1.00 or less is obtained (Spinelli, 1983). Moreover, according to Rayens and Hahn (2000), the consensus is achieved if;

i. IQD of 1.00 for more than 60% of experts who answered it with agreement or disagreement.
ii. More than 60% consensus or agreement.

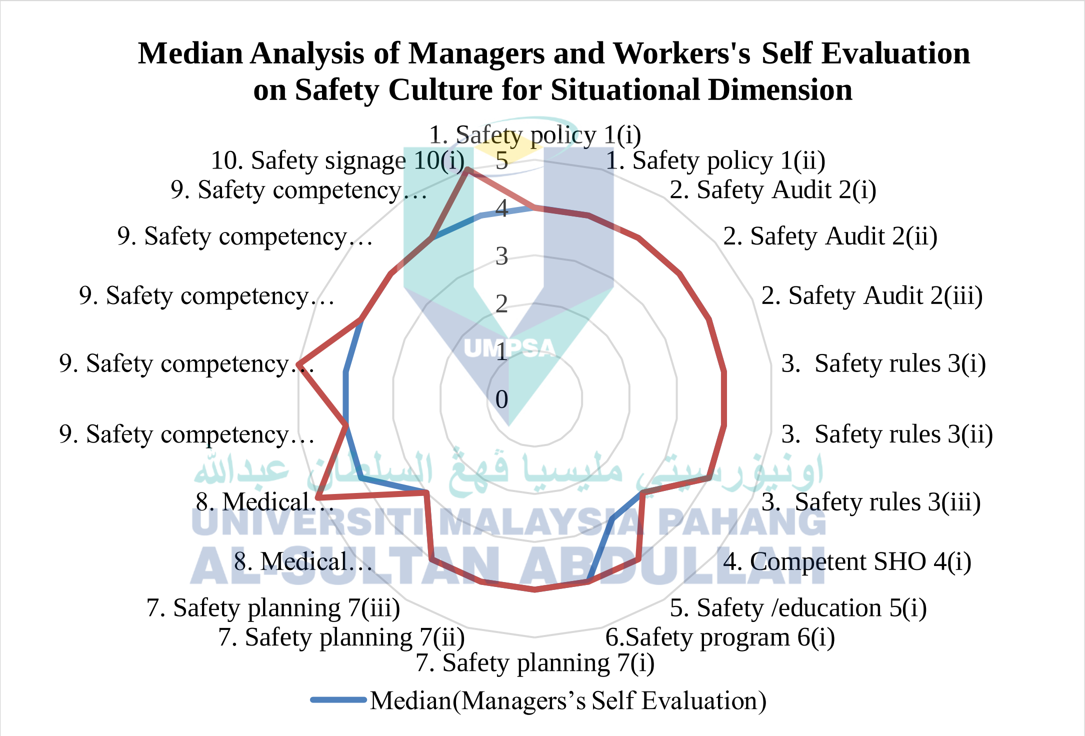


Figure 4.19 Median analysis for Managers and Workers' Perceptions on Situational Dimension

According to Lamers et al. (2016), the level of consensus for 5 points Likert's scale can be analysed based on the median as categorised: (i) Median >3: consensus on agreement with a statement, (ii) Median = 3: no consensus on agreement with a statement and (iii) Median < 3: consensus on disagreement with a statement. Moreover, based on Figure 4.18, the median analysis shows the managers and workers' perceptions of the Situational dimension at their workplace. Overall, both managers' self-evaluation and workers' evaluations of managers achieved a high level of consensus on the safety culture at their workplace since the median was bigger than 3, which means that the consensus on agreement with a statement had been achieved. Based on these findings, the managers of the mining company have provided a good safety policy, safety rules, safety signage, medical surveillance, and many more to ensure safety is their main priority at the mine site. These agreed with the evaluation of mine workers by their managers. To conclude, the agreement was achieved because, according to Rayens and Hahn (2000), the consensus achieves is more than 60% consensus or agreement has been obtained.

4.6.5.3 Analysis and Discussion on Behavioural Dimension at a Volunteered Mining Company

The Situational part questionnaire survey consists of nine main sub-factors for Managers and Workers' Perceptions. By using 5 points of Likert's scale with one being 'strongly disagree' and five being 'strongly agree', the results and individual ratings for Behavioural dimension are shown in Table 4.34.

Table 4.34 Questionnaire survey results for Manager's and Worker's Perceptions on Behavioural Dimension

Behavioural Dimension										
Factors	**No.**	**Question**	**Manager' Self Evaluation**				**Workers Evaluating Managers**			
			Median	***Mean***	***SD***	***IQD***	***Median***	***Mean***	***SD***	***IQD***
1. Management Action	1(i)	[I / My manager]* committed to ensure all my workers able to understand, apply and support the established OH&S policy and OH&S objectives of the company.	4.00	4.33	0.58	0.50	4.00	4.33	0.50	1.00
	1(ii)	[I / My manager*] always examine the resources required (eg: financial, infrastructure, equipment, safety budget) to achieve OH&S policy and objectives of the company	4.00	4.33	0.58	0.50	4.00	4.33	0.50	1.00
	1(iii)	[I / My manager*] have allocation or budget to support the intended outcome of OH&S policy and objectives of the company	4.00	4.00	1.00	1.00	4.00	4.44	0.53	1.00

Table 4.34 Continued

Behavioural Dimension										
Factors	No.	Question	Manager' Self Evaluation				Workers Evaluating Managers			
			Median	Mean	SD	IQD	Median	Mean	SD	IQD
	1(iv)	[I / My manager*] show the commitment by providing the resources needed for the establishment, implementation, maintenance and continual improvement of the OH&S management system.	4.00	4.33	0.58	0.50	4.00	4.44	0.53	1.00
	1(v)	[I / My manager*] established a planned response to emergency situations including the provision of first aid which is important in mining industry.	4.00	4.00	1.00	1.00	4.00	4.00	0.87	2.00
	1(vi)	[I / My manager*] believe I am responsible for preventing mining accidents at my company.	4.00	4.00	0.00	0.00	4.00	4.33	0.50	1.00
2. Safety communication	2(i)	[I / My manager*] ensure the OH&S policy, objectives, requirements and information are well documented and easily accessed by workers	4.00	4.00	1.00	1.00	4.00	4.33	0.50	1.00
	2(ii)	[I / My manager*]believe on communicating relevant safety information to contractors, visitors, emergency response services, government authorities and the local community is important to create a safety culture	4.00	4.33	0.58	0.50	4.00	4.44	0.53	1.00
	2(iii)	[I / My manager*]believe on the continuous dissemination and communication of OH&S information of company to all workers is important to create a safety culture at workplace.	4.00	4.00	0.00	0.00	4.00	4.11	0.93	2.00
	2(iv)	[I / My manager*] hold regular safety meetings on the job site for the mine workers	4.00	3.67	0.58	0.50	4.00	3.78	0.83	1.00
	2(v)	Formal and informal safety feedback is provided frequently by [me / My manager*] to the workers	4.00	4.00	0.00	0.00	4.00	4.11	0.33	0.00

Table 4.34 Continued

Behavioural Dimension										
Factors	No.	Question	Manager' Self Evaluation				Workers Evaluating Managers			
			Median	Mean	SD	IQD	Median	Mean	SD	IQD
	2(vi)	[I am / My manager*] open to safety feedback/ requests form the mine workers	4.00	4.00	1.00	1.00	4.00	4.44	0.53	1.00
3. Leadership	3(i)	[I / My manager*]have appointed a competent Safety and Health Officer in supporting OH&S management system including OH&S policy and objectives.	3.00	3.00	0.00	0.00	4.00	3.78	0.44	0.00
	3(ii)	[I / My manager*] have/has* appointed a competent Mine Manager/ Supervisor in supporting OH&S management system including OH&S policy and objectives.	4.00	4.33	0.58	0.50	4.00	4.00	0.87	2.00
4. Safety training	4(i)	[I / My manager*] committed to have competent workers by providing adequate and appropriate education and training.	4.00	4.00	0.00	0.00	4.00	4.33	0.50	1.00
	4(ii)	[I / My manager*] believe(s) the competence requirements, training needs, training and evaluating training for mine workers are important to construct safety culture at workplace.	4.00	4.00	0.00	0.00	5.00	4.56	0.53	1.00
5. Safety awareness	5(i)	[I / My manager*] believe (s) all workers give full commitment and comply with the relevant OH&S policy/ procedure, legal requirement and other requirement of company while performing their job.	4.00	4.00	0.00	0.00	4.00	4.33	0.50	1.00
	5(ii)	[I / My manager*] believe (s) each level of workers is aware and have clear understanding on the OH&S policy and objectives of company.	4.00	3.67	0.58	0.50	4.00	3.89	0.93	2.00
	5(iii)	[I / My manager*] believe all workers are able to apply and comply relevant OSH legal requirements and other requirement while performing their job.	4.00	4.00	0.00	0.00	4.00	4.33	0.50	1.00

Table 4.34 Continued

Behavioural Dimension										
Factors	No.	Question	Manager' Self Evaluation				Workers Evaluating Managers			
			Median	Mean	SD	IQD	Median	Mean	SD	IQD
	5(iv)	[I / My manager*] believe by eliminating hazards and reduce OH&S risks are important for safety culture.	4.00	4.00	0.00	0.00	4.00	4.44	0.53	1.00
6. Safety reporting	6(i)	[I / My manager*] ensure all incidents, non-compliance and non-conformity are investigated quickly in order to improve safety at workplace as soon as possible. Preventive reports are recommended for future reference	4.00	4.33	0.58	0.50	5.00	4.78	0.44	0.00
	6(ii)	[I / My manager*] ensure any safety concerns raised are treated with high urgency in company.	4.00	4.00	0.00	0.00	4.00	4.44	0.53	1.00
	6(ii)	[I / My manager*] support the occupational health and safety culture and encourage workers to report incidents in a timely manner.	4.00	4.33	0.58	0.50	4.00	4.44	0.53	1.00
7. Safety promotion	7(i)	[I / My manager*] ensure the activities or events such as safety week, safety seminar, safety talk are actively promoting safety culture at my company	3.00	3.00	1.00	1.00	3.00	3.33	0.50	1.00
8.Enforcement on safety rules	8(i)	[I / My manager*] believe by wearing proper PPE and understand the instructions of wearing PPE are actively promoting safety culture in my company	4.00	4.33	0.58	0.50	5.00	4.22	0.97	2.00
9.Reward and punishments	9(i)	[I / My manager*] acknowledge and reward the workers based on the contribution and commitment towards OH&S management system including the benefits if improved OH&S performance of the mining company	4.00	3.67	0.58	0.50	3.00	3.22	0.67	1.00

Based on Table 4.34, in overall means and standard deviations, a decrease in standard deviations between rounds indicates an increase in agreement on the statement (Rayens and Hahn, 2000) for both managers' self-evaluation and workers' evaluation of managers. According to the Interquartile (IQD), the level of consensus on statements also showed both managers and workers agreed on statements for each row. Consensus is achieved if an IQD of 1.00 or less is obtained (Spinelli, 1983). Moreover, according to Rayens and Hahn (2000), the consensus is achieved if;

iii. IQD of 1.00 for more than 60% of experts who answered it with agreement or disagreement.

iv. More than 60% consensus or agreement.

According to Lamers et al. (2016), the level of consensus for 5 points Likert's scale can be analysed based on the median as categorised: (i) Median >3: consensus on agreement with a statement., (ii) Median = 3: no consensus on agreement with a statement, and (iii) Median < 3: consensus on disagreement with a statement. Moreover, based on Figure 4.19, the median analysis shows the managers and workers' perceptions of the Behavioural dimension at their workplace. Overall, both managers' self-evaluations and workers' evaluations of managers achieved a high level of consensus on the safety culture at their workplace since the median was bigger than 3, which means the consensus on agreement with a statement had been achieved.

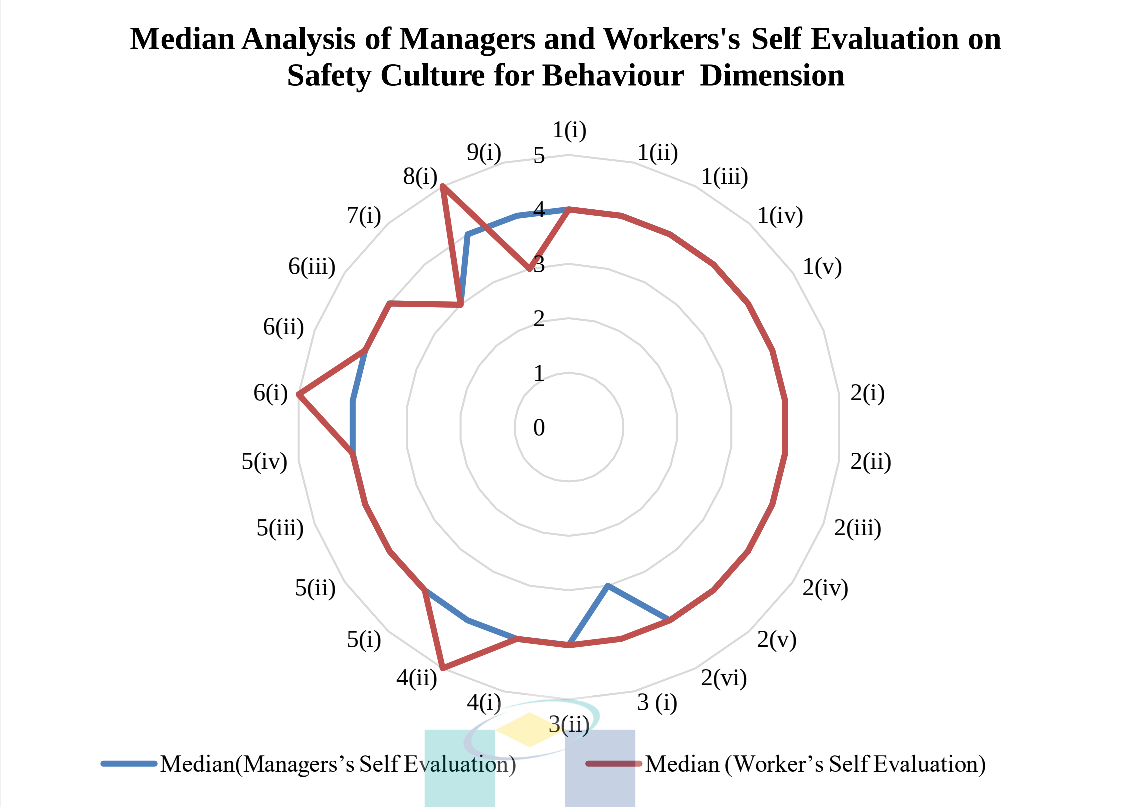


Figure 4.20 Median Analysis for Managers and Workers' Perceptions on Behavioural Dimension

4.6.6 Analysis and Discussion on AHP for Managers at a Volunteer Mining Company

Based on the observation and safety culture documentation, there is no empirical study to support the influencing factors of safety culture at a volunteered mining company. Therefore, the researcher decided to conduct a questionnaire survey previously for managers and workers. The next study was to conduct the AHP survey for Managers (Chairman, Managing Director, Plant Manager) only to understand the most influencing or significant safety culture factors at their mining company. The AHP results were later compared with the previous AHP results from Section 4.4.4 to validate the findings empirically.

4.6.6.1 Analysis on AHP for Volunteered Mining Company

The first and second steps of AHP were to determine the main goal and set up the criteria, respectively. Therefore, the main goal of AHP was to prioritise the main and sub-criteria, or factors, for each psychology, situation, and behaviour of the safety culture dimensions. The third and fourth steps were the hierarchy and pairwise comparison. For the sub-criteria of the Psychological and Situational Safety Culture, they were totally accepted due to CR <0.1 or 10%. However, the main criteria and sub-criteria of behaviour were obtained at 0.292 and 0.212, respectively, which are more than 0.1. The AHP survey was sent to only three managers and may have had a great influence on the resulting CR >0.1. This was supported by the previous scholar who mentioned that the small number of participants in AHP may result in a higher CR and can be accepted (Ho et al, 2015).

Table 4.35 Overall Results of Consistency Ratio (CR value) for mining company X

Item	**No of matrices (n)**	**Consistency Ratio (CR)**
Main criteria	3	0.292
Sub-criteria for Psychology	5	0.033
Sub-criteria for Situational	9	0.061
Sub-criteria for Behavioural	10	0.212

For main criteria with a CR of 0.292, which is bigger than 1.0, may happen depending on the nature and objective of the research (Geopel, 2017). Geopel (2017) mentioned that CR can practically go up to 20% (CR>0.2) Furthermore, according to Page (2015), the CR value can be up to 30% (CR>0.3) and also be accepted. For sub-criteria of behavioural where CR was 0.212 and bigger than 1.0, it may happen due to the large matrices used (10 x10 matrices). CR depends mainly on the matrix size, following the recommendations of Wedley (1993). In addition, it depends on the sample characteristics and the analysis (group and/or individual). For individual experts, CR is restricted to 0.10 or 0.15, while for group responses, CR could be relaxed to 0.20 to allow for non-expert responses following the recommendations by Ho et al. (2005). They added that it is advisable to avoid comparing more than nine elements and that it is easier to be consistent on a smaller set of comparisons. For these sub-criteria, the 10 x10 matrices of influencing factors were used and considered big matrices which may contribute to the higher CR >1.0. Furthermore, Table 4.36 shows the rank of the main criteria and sub-criteria for a volunteered mining company. The five significant factors of safety culture in mining were (1) Safety education, (2) Safety policy, (3) Safety planning, (4) Competent SHO, and (5) Safety rules. These prioritised safety culture factors were significant as a result of feedback from the Chairman, Managing Director, and Plant Manager of mining company X. The results could benefit the company for further improvement to ensure a safety culture exists at their mine site and prevent any injuries and accidents, such as through empowerment of safety education and enforcement of safety policies for all mine workers.

Table 4.36 Rank of Main criteria and sub-criteria for a volunteered mining company

Main criteria (Local weight)	Weight of Main Criteria (Rank)	Sub-main criteria	Symbol	Local Weight	Global Weight	Overall Rank based on Global Weight
Situational	0.67 (1)	1. Safety policy	PO	0.118	0.079	2
		2. Safety audit	AU	0.043	0.029	13
		3. Safety rules	SR	0.100	0.067	5
		4. Competent SHO	SO	0.106	0.071	4
		5. Safety education	SE	0.170	0.114	1
		6.Safety programme	PR	0.094	0.063	6
		7. Safety planning	PL	0.110	0.074	3
		8. Medical surveillance	MS	0.087	0.058	7
		9. Safety competency	CO	0.085	0.057	8
		10. Safety signage	SS	0.087	0.058	7
Behavioural	0.25 (2)	1. Management action and responsibility	MA	0.133	0.033	12
		2. Safety communication	SC	0.138	0.034	11
		3. Leadership	LE	0.093	0.023	13
		4. Safety training	TR	0.133	0.033	12
		5. Safety awareness	AW	0.212	0.053	9
		6. Safety reporting	RE	0.023	0.006	19
		7. Safety promotion	SP	0.062	0.015	15
		8. Enforcement on safety rules	EN	0.157	0.039	10
		9. Reward and punishment	RP	0.049	0.012	17
Psychological	0.08(3)	1. Management care on workers	MC	0.213	0.017	15
		2. Safety attitude	SA	0.176	0.014	16
		3. Job satisfaction	JS	0.209	0.017	15
		4. Health of worker	HW	0.123	0.010	18
		5. Peer influence	PI	0.279	0.022	14

4.6.6.2 Validation and Comparison on Prioritised Factors of Safety Culture

Table 4.37 shows the comparison of the overall results of the consistency ratio (CR value) for AHP panel experts and top management from a volunteered mining company. Based on the table, the results were accepted even though some of the sub-criteria or main criteria were slightly bigger than 1.0, as discussed previously in Subsection 4.6.6.1.

Table 4.37 Comparison of Overall Results of Consistency Ratio (CR Value) for AHP Panel Experts and Volunteered Mining Company

Item	No of matrices (n)	CR for AHP panels (5 panels)	CR for AHP at a Volunteered mining company (3 managers)
Main criteria	3	0.000	0.292
Sub-criteria for Psychological	5	0.059	0.033
Sub-criteria for Situational	9	0.133	0.061
Sub-criteria for Behavioural	10	0.136	0.212

Furthermore, Table 4.38 shows the comparison on rank of main criteria and sub-criteria for AHP panel experts and managers from a volunteered mining company. Based on Table 4.38, the AHP expert agreed that (1) Safety Attitude, (2) Leadership, (3) Enforcement of safety rules, (4) Safety awareness, and (5) Reward and punishment were the top five prioritised safety culture factors, which came from the psychological and behavioural safety culture dimensions. In contrast, the top five of prioritised factors of safety culture for mining company X were (1) Safety education, (2) Safety policy, (3) Safety planning, (4) Competent SHO, and (5) Safety rules, all of which fell under the situational safety culture dimension. The findings were totally different from the results from AHP experts. These findings were discussed among the Chairman, Managing Director, and Plant Manager of mining company X.

Table 4.38 Comparison on Rank of Main criteria and sub-criteria for AHP Panel Experts and Volunteered Mining company

Main criteria (Local weight)	Weight of Main Criteria (Rank)	Sub-main criteria	Symbol	Local Weight		Global Weight		Overall Rank based on Global Weight	
				AHP Panel	Mining company X	AHP Panel	Mining company X	AHP Panel	Mining company X
Behavioural	AHP Panel 0.46 (1) Mining company 0.25 (2)	1. Management action and responsibility	MA	0.101	0.133	**0.047**	0.033	6	12
		2. Safety communication	SC	0.054	0.138	**0.025**	0.034	13	11
		3. Leadership	LE	0.179	0.093	**0.083**	0.023	2	13
		4. Safety training	TR	0.103	0.133	**0.047**	0.033	6	12
		5. Safety awareness	AW	0.148	0.212	**0.068**	0.053	4	9
		6. Safety reporting	RE	0.063	0.023	**0.029**	0.006	12	19
		7. Safety promotion	SP	0.095	0.062	**0.044**	0.015	7	15
		8. Enforcement on safety rules	EN	0.150	0.157	**0.069**	0.039	3	10
		9. Reward and punishment	RP	0.107	0.049	**0.049**	0.012	5	17
Situational	AHP Panel 0.32 (2) Mining company 0.67 (1)	1. Safety policy	PO	0.071	0.118	**0.023**	0.079	15	2
		2. Safety audit	AU	0.123	0.043	**0.039**	0.029	9	13
		3. Safety rules	SR	0.090	0.100	**0.029**	0.067	12	5
		4. Competent SHO	SO	0.073	0.106	**0.024**	0.071	14	4
		5. Safety education	SE	0.114	0.170	**0.037**	0.114	10	1
		6.Safety programme	PR	0.115	0.094	**0.037**	0.063	10	6
		7. Safety planning	PL	0.102	0.110	**0.033**	0.074	11	3
		8. Medical surveillance	MS	0.130	0.087	**0.042**	0.058	8	7
		9. Safety competency	CO	0.115	0.085	**0.037**	0.057	10	8
		10. Safety signage	SS	0.067	0.087	**0.021**	0.058	16	7
Psychological	AHP Panel 0.22(3) Mining company 0.08 (3)	1. Management care on workers	MC	0.196	0.213	**0.042**	0.017	8	15
		2. Safety Attitude	SA	0.437	0.176	**0.095**	0.014	1	16
		3. Job satisfaction	JS	0.093	0.209	**0.020**	0.017	17	15
		4. Health of worker	HW	0.203	0.123	**0.044**	0.010	7	18
		5. Peer influence	PI	0.071	0.279	**0.015**	0.022	18	14

According to the Plant Manager, he agreed with the prioritised factors from the AHP experts, such as the safety attitude of mine workers, which is important, as well as the leadership of the Supervisor or Safety Health Officer, to ensure that a safety culture can be developed. Even though the ranking of factors is different, he agreed with the prioritised factors of safety culture obtained from the AHP experts. He agreed that the enforcement of safety rules is important, and they agreed with the findings obtained from the AHP experts. Safety awareness and reward and punishment are also significant. He also mentioned that their company does not give rewards to the workers that abide by the rules; therefore, it is a good effort to motivate their foreign workers to follow the safety rules, such as wearing proper PPE while working at the mine site.

For their mining company, they also agreed that they required good safety education for workers at the first rank. Safety education is important to his company because it educates foreign workers, as well as local workers. Most foreign workers do not have a proper educational background; therefore, his company aims to educate and train them by providing proper safety education and training since they have the allocation or budget for it. Moreover, the Managing Director of mining company X mentioned they need to strengthen their safety policy as their second prioritised factor to ensure their mining operation can run smoothly and always keep up-to-date with the government's rules and local authorities. Moreover, this is to ensure the workers can work in a safe working environment. He also mentioned that a competent SHO is important for their company. Safety planning and competent SHO were ranked in third and fourth places. Even though they have a Safety Manager to monitor and plan the safety activities among workers, SHO also helps the company in terms of safety planning and activities throughout the year. The fifth prioritised factor was safety rules, which is related to safety policy. They faced problems with the foreign mine workers, such as those from China and Bangladesh, who always ignored the safety rules, such as not wearing proper PPE while performing the job at the mine site.

Even though the numbers of ranked companies were different as a result of their nature of mining activities and the business operations of the mining company itself. Every mining company is unique and has its own constraints and issues. The mining company X showed the most prioritised factors of safety culture: (i) safety education, (ii) safety policy, (iii) safety planning, (iv) safety rules, and (v) safety audits. These five significant factors of safety culture could help the mine owner of mining company X focus and make some improvements for their betterment in the future to avoid mining injuries or accidents.

4.6.7 Concluding Remarks for Case study

The case study was successfully conducted at mining company X. The observation was done to assess the safety culture practises at the excavation and mineral processing areas only. A further step was conducting surveys for both managers and workers at the excavation and mineral processing areas. Based on the results of the questionnaire survey, it can be concluded that the perceptions on safety culture among both managers and mine workers are in good conditions. In addition, the mining company X also conducted an AHP survey for managers only. The final step was an interview session with the top management to table all the findings and validate the proposed framework. Based on the interview session, all the managers agreed and validated the framework. They hope the validated framework could benefit the mining industry.

4.7 Safety Culture Framework for Mining industries in Malaysia

The research on safety culture has been successfully conducted with a series of research methods consisting of (i) a preliminary study, (ii) Delphi I and II, (iii) prioritised safety culture using AHP, (iv) FGD session, and lastly, (v) a case study at a volunteered mining company X. The construction of a safety culture framework was validated through an FGD session and a case study at mining company X. The validated safety culture framework for mining industries in Malaysia is illustrated in Figure 4.20.

Overall, the study found three main safety culture dimensions, namely (i) psychological (5 factors), (ii) situational (9 factors), and (iii) behavioural (10 factors), to construct a safety culture framework in the mining industry in Malaysia. The details of the discussion on each factor are discussed previously in Sections 4.2.3 to 4.2.5. Based on Figure 4.20, the involvement of four (4) main references, namely; (i) act, (ii) standard, (iii) guidelines, and (iv) mining experts, is useful to develop a safety culture framework in this study.

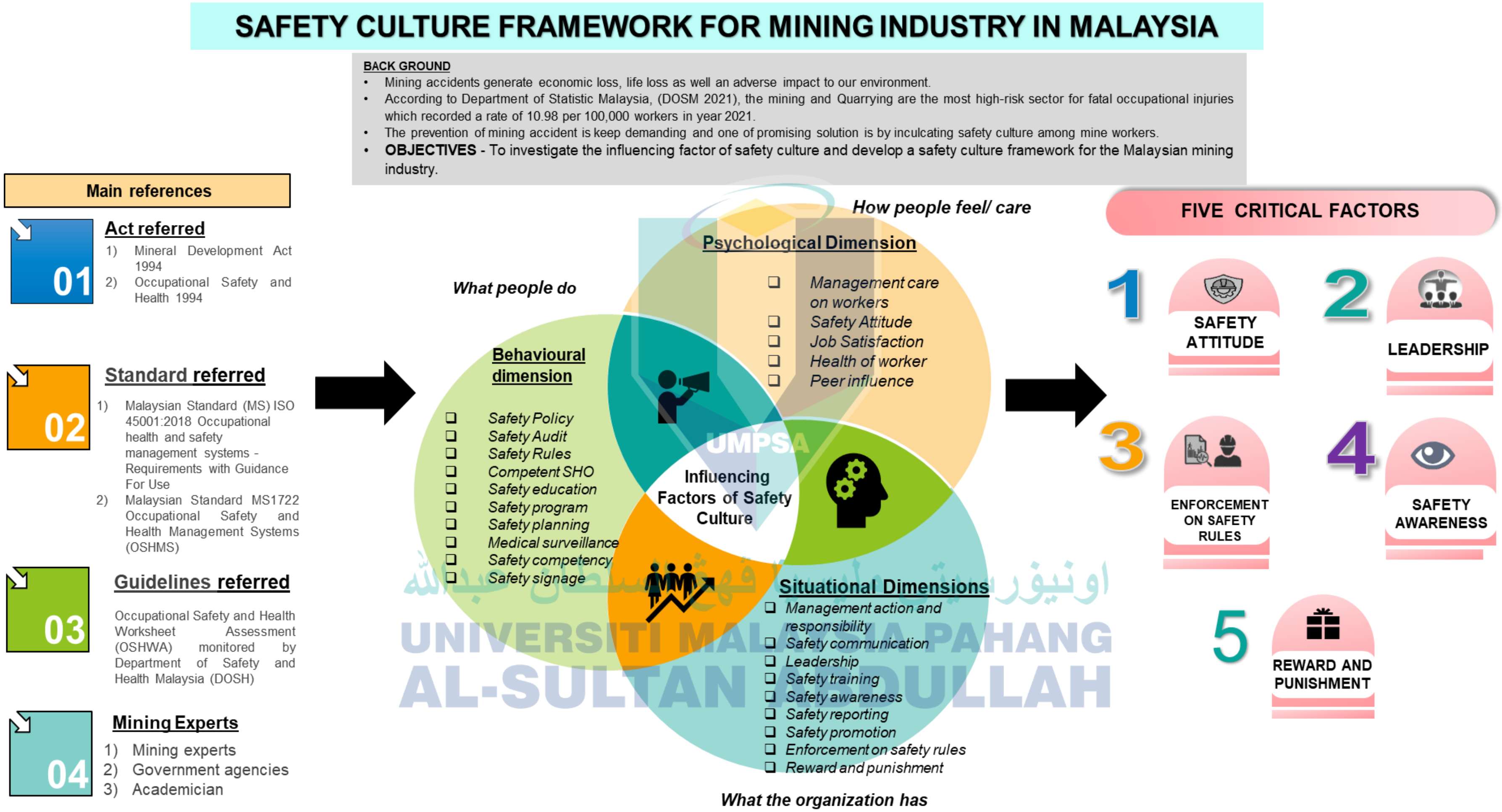


Figure 4.20 Validated safety culture framework in mining industry in Malaysia

In this study, two acts were referred in order to construct a safety culture framework: (i) Mineral Development Act 1994 and (ii) Occupational Safety and Health 1994. These acts were carefully referred to understand the clauses or sentences that relate to safety culture factors and can be reflected in the safety culture dimensions (psychological, situational, or behavioural) and influencing factors of safety culture found in this study. For example, according to the Occupational Safety and Health Act (OSHA) of 1994 and Factory Machinery Act (FMA), the mining industry is not required to appoint a safety and health officer (SHO). The latest amendment was FMA, which was already abolished, and the content of FMA was embedded into OSHA 2022. The findings revealed that the appointment of a competent SHO is important to construct a safety culture in the mining industry, as shown in Figure 4.20. According to the Senior Operating Mining Manager (R1), who has 25 years of working experience in the mining industry, it is important to have a competent SHO at a mining company to build a safety culture. He mentioned:

> *'There is a problem in the mining industry where the mine manager himself does not stress the importance of safety aspects in mining operations, especially for small-scale mining operations. Under Occupational Safety and Health Act (OSHA 1994) and Factory Machinery Act (FMA), the mining industry is not required to appoint a safety and health officer (SHO). Therefore, we can see that small-scale mining companies have neglected the safety aspect and have a poor safety culture. It becomes worse because nobody is responsible for the safety issues at the mine site. In contrast, large-scale mining operations have a proper safety policy and had hired a competent mine manager and SHO to ensure safety, which is one of their main concerns. This is because they have financial stability compared to small-scale mining operations.'*

The feedback from mining experts in Delphi I such as Safety Manager (R2), also mentioned the importance of SHO in the mining industry and how it is useful to build safety culture. Even though it is not a requirement for the mining industry to have SHO, based on his experience he suggested;

> *"to build a good safety culture, the mine owner or operator must appoint a competent SHO".*

Appointing a competent SHO is responsible for helping the mine owner run the safety operation of the mining company smoothly. SHO could monitor the safety aspect and safety practises at the workplace responsibly. Besides, SHO is responsible for the safety planning or activities for the mining company, such as organising the safety week, safety training, safety competency, and focusing on the enforcement of safety rules at the mine site.

The second act referred to in this study is the Occupational Safety and Health Act of 1994 ("OSHA"). The OSHA 1994 was made in consideration of the fact that the FMA 1967, which provides control of factories and only covers sectors such as manufacturing, mining, quarrying, and construction. The duty imposed by OSHA 1994 on the employer or self-employed person is *"to ensure, so far as is practicable, the safety, health, and welfare at work of all his employees,"* which is reflected in the responsibility or management commitment to provide a good working environment to the mine workers. This is one of the main elements in this framework under the Situational dimension *"what the organisation has"*. Even though the environment of mining operations or activities at the mine site is harsh with high potential for risk and hazards, this is not the main barrier or excuse for the mine operator or mine owner to neglect safety aspects. For example, the mine owner must provide complete Personal Protective Equipment (PPE) for all mine workers. This is also one of the important influencing factors of safety culture in this framework and reflects the safety policy and safety rule factors found in this study.

Furthermore, this act also stresses the health and welfare of employee aspects, which is in this framework are referred to as mine workers. The health of employees reflects the psychological dimension "*How people feel/care"* and the behavioural dimension *"What people do*". For example, the factors of management care on workers and the health of workers fall under the Psychological dimension, which reflects the importance of mine owners taking care of the health and welfare of mine workers, including their physical and mental health issues. In addition, the Behavioural dimension which stresses on *"what people do,"* can refer to the responsibility of the mine owner to their workers, such as conducting annual medical check-ups under the medical surveillance factors. This factor is important, as mentioned by the mining experts during Delphi I. For example, the Chief Geologist cum former Mining Manager (R21) stated *"the mine owner must do annual check- up to the mine workers".* This was also agreed upon by a few mining experts, such as the Safety Manager (R2) and the Professional Geologist cum Senior Lecturer (R8) at one of the local universities in Malaysia.

For the second reference used, there were two main standards, which are;

1) Malaysian Standard (MS) ISO 45001:2018 Occupational Health and Safety Management Systems - Requirements with Guidance for Use
2) Malaysian Standard MS1722: Occupational Safety and Health Management Systems (OSHMS)

Both of these standards were useful for the researcher to understand an up-to-date information and safety practises related to occupational health and safety management. It also helps the researcher construct the questionnaire survey on safety culture, which was successfully completed in Delphi II. Moreover, the researcher also used guidelines from the Department of Safety and Health Malaysia (DOSH), namely; Occupational Safety and Health Worksheet Assessment (OSHWA), as a third reference to construct a safety culture framework for the mining industry in Malaysia.

For the fourth reference, the involvement of mining experts was very significant in constructing this framework. The first-hand input from mining experts was very valuable in this study. Three categories of mining experts consist of mining industrial personnel, government agencies, and academicians with a total of 58 experts contributing their experience, guidance, and expertise related to safety culture during the preliminary stage until the case study at mining company X. They consist of;

<u>1) Mining players from industry</u>

- Mine operator, Mine owner, Chairman of mining company, Managing Director of mining company, Senior Operating Mining Manager, Vice President Business Development (Mining), Mining Consultant (gold, coal, tin), Mine Manager, Senior Chief Geologist cum Mining Manager, Senior Geologist, Grade Control Superintendent (Geologist),, Technical Consultant in mining, Chief Operational Officer, Plant Manager, Senior Mining Engineer, Mining Engineer, Contract Mining Manager, Safety/HSE Manager, OSHE Training Consultant, EHS Superintendent, Safety Health Officer

2) Government agencies

- Director of Jabatan Mineral dan Galian (JMG) Pahang, Former Deputy Director of JMG, Head of Researcher for Mineral Development, Assistant Director (Mines and Quarry), Department of Safety and Health Malaysia (DOSH)

3) Academician

- Professors from UMS and USM, Associate Professor from UiTM, Senior Lecturer from UKM and USM

Referring to Figure 4.20, the safety culture framework was successfully developed and consists of three main safety culture dimensions with 24 influencing factors. All 24 factors later on were prioritised by using the Analytical Hierarchy Process (AHP), as discussed previously in Sections 3.5 and 4.4. Based on Figure 4.20, 5 out of 24 factors were identified as critical factors or the most influencing factors to establish a safety culture in the mining industry in Malaysia. The top five critical factors to create a safety culture, are: (i) safety attitude, leadership, (iii) enforcement on safety rules, (iv) safety awareness, and (v) reward and punishments. All these factors were agreed upon and validated by experts in the FGD discussion.

Based on OSHE Training Consultant (E3) with 20 years of experience, she agreed with the findings, and she did mention safety attitude as the main factor in creating a safety culture. She said;

> *"Safety attitude among mine workers are still low and need to be improved. They prefer short cut method, still break the rules". She added; "Leadership of mine owner is very important to give clear direction on the safety at workplace. I also agreed the enforcement, safety awareness must be done to build safety culture."*

She also added;

> *"Main problem for top management is they have business background and business minded and mostly they have purely business knowledge and not concern about safety. They lack of safety knowledge and safety awareness. Their knowledge only how to make money, make profit. So, if the top management do not commit with safety concerns, there is no safety awareness exists. So, safety awareness must come from top management and later he will commit on safety issues".*

In addition, the FGD expert (EI) agreed with the list of factors and raised his concern as stated;

> *"I agree with all the factors but the problem here is how we can synchronize all these things. Even though we have a good law (rules and regulations), the main problem is the safety attitude. If we want to achieve a good safety culture, we need to change their (mine worker) attitude first".*

He added;

> *"I can see the mining problem (to create safety culture) is safety attitude of mine workers itself. The leadership of top management is important as well as the safety awareness. Reward and punishment also help to create a safety culture at mining industry"*

Furthermore, the framework was also discussed and validated during the case study at mining company X. According to the Chairman of the company;

> *"I agree and validate with all these factors and don't have any issues. The framework was touching all important factors to establish safety culture at mining industry such as safety attitude, management commitment, safety policy as mentioned here"*

The Plant Manager of mining company X stated;

> *"I agree with all the important factors in this framework. I also agree with the five main prioritised factors such as safety attitude, leadership as mentioned here. For our company we have issue on safety education as mentioned by you (refer to AHP results of mining company X), so we need to educate the foreign workers about on safety such as wearing PPE, hold a talk on safety and so on".*

By referring to this validated framework, the safety culture in the mining industry in Malaysia can be developed. It can be ideal if all mining companies whether small-scale or large-scale are aware of the importance of having a good safety culture at the workplace and directly prevent mining accidents or disasters. However, in reality, the mining business and operations of each mining company are not the same. Therefore, the factors found in this study cannot be generalised and practised by all mining companies. For example, in Delphi I, the Senior Operating Mining Manager (R1) with 25 years of experience in the mining industry did mention that it is difficult to merge and standardise the practise of safety culture in mining companies due to a huge gap between small and large-scale mine operations in Malaysia. The lack of awareness and understanding of the importance of OSH at the workplace from a business and legal perspective is the major constraint on the implementation of a safety culture in small-scale mine operations. The mine operators or mine owners of small-scale mine operations are eager to get a very fast rate of return, so they left behind the safety aspect. Some small-scale mine owners were inherited by their previous ancestors or families; therefore, they are reluctant to accept the changes and prefer to continue their own working lifestyle and neglect the safety aspects. At this particular point, their previous education and attendance at safety training will give them self-awareness regarding the importance of safety culture in mining company.

In contrast, large scale mine operations in Malaysia seem more systematic in their management due to well-planned top management and strong financial resources, but the challenges may come from engagement between employer and employees. Furthermore, according to mining experts, the lack of enforcement by the local authorities and government agencies can also hinder the formation of a safety culture in mining organisations. Incompetent leaders such as mine supervisors, safety officers, and mine managers are also failure factors in the safety culture of organisations. For example, the leader does not understand well the nature of mining operations, fails to supervise the workers, fails to plan and implement the safety programme, and lacks knowledge and competency. These factors can usually be seen in small-scale mine operations in Malaysia.

The validated safety culture framework is useful to mining companies by giving them awareness of the influencing factors that might be useful or suit their company and some improvements that they need to focus on. This framework also helps to foster or educate the mine owners and mine workers become responsible miners who always prioritise safety aspects while performing their jobs. This framework also includes some sort of effort to standardise the safety culture practises between small-and large-scale mine operations in the mining industry in Malaysia and close the gap between them. By presenting this validated safety culture framework, it could benefit mining companies and provide a new paradigm for the mining industry to have this framework as a reference to improve their current safety practises.

Moreover, this framework could also help prevent mining accidents or disasters in the future, as well as educate mine workers to become responsible miners. This framework is very useful if the Malaysian government strengthens its enforcement and monitoring of the mining industry, which is found to be one of the five critical factors for building a safety culture framework in this study. Promotion of safety culture awareness as one of the five critical factors in this framework can be done at the state or national level. It is important to create a safety culture in mining companies, change the mindset of mine owners and workers, and also help to change their perspective towards having a good safety attitude.

4.8 Conclusion for Chapter 4

Overall, the preliminary study, Delphi I, Delphi II, AHP study, FGD session, and case study were successfully completed with significant contributions from the mining experts for each study. Moreover, the safety culture framework was also successfully developed and validated in this study.

CHAPTER 5

CONCLUSION

5.1 Introduction

The objectives, research questions, and hypothesis of the study were achieved. The main objective of the study was to develop a safety culture framework for the mining industry in Malaysia. The study adopted a mixed-method approach to achieve its five objectives. An extensive literature review, Systematic Literature Review (SLR), Delphi I and Delhi II were carried out. The Focus Group Discussion (FGD) and case study were conducted in order to validate findings from the Delphi study and AHP with regard to the influencing factors necessary to construct a safety culture framework in the mining industry in Malaysia for psychological, situational and behavioural dimension. Figure 5.1 shows the main summary of the findings and conclusion of this study. Conclusions regarding the study are presented relative to the objectives of the study in the following sections.

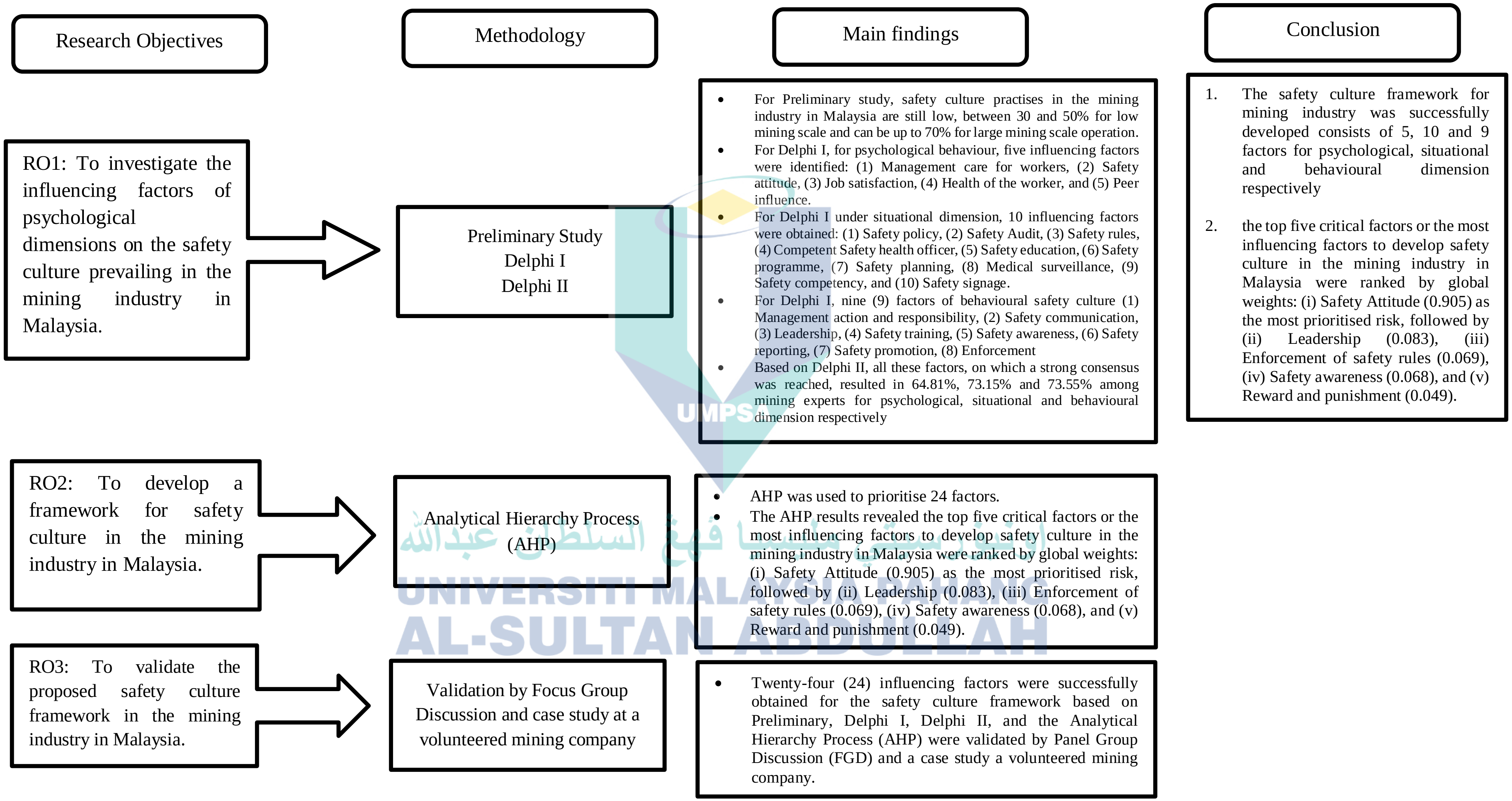


Figure 5.1 Conclusion for study

5.1.1 Conclusion for Research Objective (RO1)

The first objective of the study was to investigate to investigate the influencing factors of psychological, situational and behavioral dimensions on the safety culture prevailing in the mining industry in Malaysia. With regards to psychological dimension, *What are the main psychological factors used to develop the framework of safety culture that could have a significant impact on fostering safety in the mining industry of Malaysia?* The Literature Review (LR), Systematic Literature Review (SLR), Preliminary Study, Delphi I and Delphi II were conducted to answer RQ1 and achieve RO1.

The safety culture framework adopted the Cooper Safety culture model (Cooper, 2000), which consists of psychological, situational, and behavioural dimensions. For the psychological dimension, the findings from the LR and SLR indicated that a number of factors were considered to be important in constructing a safety culture in the mining industry, such as safety attitude and peer influence. Based on SLR findings, psychological factors influenced the formation of a safety culture in the mining industry by 24%.

For the Preliminary study, six mining experts voluntarily participated as the respondents. They consist of a Former Deputy Director in the government mining sector, Technical Consultant in mining, Mining Consultant who is also a gold mine owner, a Safety and Health Officer (SHO), an Assistant Director (Mines & Quarry), a Contract Mining Manager cum former Safety and Health Officer in mining. The findings showed the urgency of having a safety culture framework since the safety culture practises in the mining industry in Malaysia are still low, between 30 and 50%. For Delphi I and Delphi II, 21 and 18 mining experts, respectively, were involved, which consisted of mine owners, mining consultants, SHOs, government agencies, and academicians from local universities. For the psychological dimension, *"What people care"* was investigated by the Delphi I and Delphi II studies, which was successfully completed. For psychological behaviour, five influencing factors were identified: (1) Management care for workers, (2) Safety attitude, (3) Job satisfaction, (4) Health of the worker, and (5) Peer influence. All these factors, on which a strong consensus was reached, resulted in 65.27% among mining experts.

For the situational dimension, the extensive review from LR and SLR indicated a few factors influenced safety culture, such as safety rules and safety environments. Based on SLR findings, the situational dimension influenced the formation of a safety culture by 29% in the mining industry. For Preliminary, Delphi I and Delphi II, 6, 21, and 18 mining experts were involved, respectively. The findings showed the urgency of having a safety culture framework since the safety culture practises in the mining industry in Malaysia are still low, between 30 and 50%. The findings indicated that a number of factors that were considered to be important in constructing a safety culture for the situational dimension *"What organisation has"* were identified and amplified by the Delphi study, which was successfully completed. For situational dimension, ten influencing factors were obtained: (1) Safety policy, (2) Safety Audit, (3) Safety rules, (4) Competent Safety health officer, (5) Safety education, (6) Safety programme, (7) Safety planning, (8) Medical surveillance, (9) Safety competency, and (10) Safety signage. All these factors, on which a strong consensus was reached, resulted in 73.15% among the mining experts.

For the behavioural dimension, the findings from the LR and SLR indicated that a number of factors were considered important in constructing a safety culture in the mining industry, such as safety training, management commitment, and reward and punishment. Based on SLR findings, the behavioural factors influenced the formation of a safety culture in the mining industry by 47%. The findings indicated that a number of factors that were considered important in constructing a safety culture for the behavioural dimension *"What people do"* were identified and amplified by the Delphi I and II studies, which were successfully completed. Nine (9) factors were considered paramount and main determinants of safety culture: (1) Management action and responsibility, (2) Safety communication, (3) Leadership, (4) Safety training, (5) Safety awareness, (6) Safety reporting, (7) Safety promotion, (8) Enforcement of safety rules (PPE), and (9) Reward and punishment. All these factors, on which a strong consensus was reached, resulted in 73.55% among the mining experts. Based on the results from RO1, these factors were collectively considered for the development of the all-inclusive safety culture framework, consists of psychological, situational, and behavioural dimensions for the mining industry in Malaysia.

5.1.2 Conclusion for Research Objective 2 (RO2)

The second research objective (RO2) was to develop a framework for safety culture in the mining industry in Malaysia. The related research question (RQ) for RO2 was *RQ2: What are the most significant influencing factors that contribute to the construction of a safety culture framework in Malaysia?*

Based on SLR, 47% of the behavioural dimension with eight factors influenced the formation of safety culture in the mining industry, followed by 29% of the situational dimension (5 factors) and 24% of the psychological dimension (4 factors). However, by applying thematic analysis according to the Preliminary study and Delphi I, 37.5% behavioural (9 factors), 41.7% situational (10 factors), and 20.83% psychological (5 factors) dimensions were obtained. Based on these findings, it was shown that the situational dimension had the greatest influence on the formation of safety culture, with the highest number of factors obtained from the study.

However, to find the critical factors of the safety culture framework, the Analytical Hierarchy Process (AHP) was used to prioritise the factors obtained in RO1 for psychological (5 factors), situational (10 factors), and behavioural (9 factors). The AHP questionnaire was designed and validated by professors who are experts in AHP research. The AHP questionnaire was distributed to mining experts who agreed to participate in the AHP study. They consist of a Mining Manager, Senior Geologist, Senior Mining Engineer, Head of Researcher for Mineral Development, and Mine Owner.

The AHP results revealed the top five critical factors or the most influencing factors to develop safety culture in the mining industry in Malaysia were ranked by global weights: (i) Safety Attitude (0.905) as the most prioritised risk, followed by (ii) Leadership (0.083), (iii) Enforcement of safety rules (0.069), (iv) Safety awareness (0.068), and (v) Reward and punishment (0.049). The safety culture framework for the mining industry in Malaysia was successfully developed, and objective RO2 was achieved.

5.1.3 Conclusion for Research Objective 3 (RO3)

The third research objective of the study was to validate the proposed safety culture framework in the mining industry in Malaysia. Twenty-four (24) influencing factors were successfully obtained for the safety culture framework based on Preliminary, Delphi I, Delphi II, and the Analytical Hierarchy Process (AHP). Based on research question 3, *RQ3: To what extent could the proposed framework of safety culture have a significant impact on the mining industry of Malaysia?* To answer RQ3 and RO3, the framework was validated by experts in the Focus Group Discussion (FGD) and conducted a case study at a volunteered mining company X in Malaysia. Five (5) FGD panels were involved and validated the framework. For the case study, the top management also agreed and validated the framework. Overall, Objective 3 was significant for mining industry and all objectives were achieved.

5.2 Contributions and Value of the Research

The value and contribution of the current research are described at three levels: the theoretical, methodological, and practical levels of the research findings. However, it is pertinent to note that the outstanding contribution of the study is to the top management of mining companies in Malaysia.

5.2.1 Theoretical Contributions

The results of the Preliminary study and Delphi I analysis indicated that of the 24 main factors to construct safety culture in Malaysia, five out of 24 belong to the psychological dimension, 10 and 9 factors to situational and behavioural dimensions, respectively. This was achieved through the following processes:

i. The compilation of extensive literature review (LR) and systematic literature review (SLR) of historical documentation on safety culture in the mining industry from various countries.

ii. The use of a mixed-method approach made up of a Delphi I study (interview) and a questionnaire survey (Delphi II). Both of Delphi used to arrive at a theoretical model. Furthermore, 24 factors were then prioritised by using AHP to find the top 5 of critical factors for developing a safety culture for the mining industry in Malaysia.

iii. Finally, an integrated safety culture framework for the mining industry was developed and validated by mining experts in an FGD session and a case study in the industry.

Findings from the LR and SLR did not reveal evidence of research conducted on safety culture in the mining industry in Malaysia. Moreover, to the best of the researcher's knowledge, there is a lack of evidence, such as scientific publications and research related to safety culture in Malaysia. Thus, it shows that the study to develop a safety culture framework in the mining industry is significant, which will assist in preventing the occurrence of mining accidents and disasters, as well as producing responsible miners in the future improving the quality and safety of work undertaken by mining companies.

Moreover, there was no evidence that the suggested sequential mixed method using Delphi, AHP, and FGD had been used by researchers in this field in Malaysia. Therefore, this study may offer a base for other researchers to use for follow-up studies. Likewise, the current study developed a safety culture framework for the mining industry with three main safety culture dimensions (psychological, situational, and behavioural) and 24 influencing factors. Apart from the study contributing to theoretical knowledge, it also contributes to methodological advancement in terms of the approach used in conducting the research, as indicated in the next section.

5.2.2 Methodological Contributions

To the best of the researcher's knowledge and based on the preliminary study, there is no safety culture framework for the mining industry in Malaysia yet. Therefore, to have a comprehensive safety culture framework, the study used sequential exploratory mixed methods to develop a safety culture framework for the mining industry in Malaysia. Findings from Delphi I and Delphi II which involved interview sessions and a questionnaire survey to investigate influencing factors of safety culture, were then prioritised using the Analytical Hierarchy Process (AHP). The questionnaire survey instrument had high internal reliability values and therefore could be used in similar studies to validate the current study or for similar purposes. The framework was then validated by the mining experts in an FGD session and a case study at a volunteer mining company. As a result of this mixed method, a safety culture framework was developed. The contribution and involvement of mining experts, government agencies, and academicians were significant in this study. Aside from this contribution and value to the body of knowledge in terms of the methodological approach, a contribution to practise in the mining industry was also achieved based on the validation from the mining experts in the FGD session and a case study at a volunteered mining company.

5.2.3 Practical Contributions and Values

AHP results indicated that Safety Attitude, (ii) Leadership, (iii) Enforcement of safety rules, (iv) Safety awareness, and (v) Reward and punishment are the top five critical factors of safety culture in mining industry in Malaysia. The safety culture framework is significant, especially for mining companies. The knowledge of the influence factors, of which 24 factors were successfully identified, could help mine owners or mine operators plan, organise, coordinate, and control all aspects relating to the safety culture practises at the mining company.

Moreover, the current practice of DOSH is to evaluate the safety aspect at mining companies by using Occupational Safety and Health Worksheet Assessment (OSHWA) forms. By intervening and introducing this safety culture framework, it can also improve the current safety assessment at mining companies by introducing a safety culture assessment for each mining company, regardless whether it is a small-scale or large-scale mining companies. The integrated and holistic safety culture framework is recommended and can be used as a guide to ensure that all mining companies abide by it as a mechanism to prevent the occurrence of mining accidents or disasters. This can also help mine workers adopt a safety culture as their way of working at the mine site. If this happens, responsible miners can be produced in the future. The study provides an opportunity for more research to enhance the framework created in this study and probably refine the factors of safety culture and suitability for their mining company. Therefore, the recommendations and policy implications for the practise of all these factors to which the current study may add value and contribute are presented in Section 5.3.3.

5.3 Recommendations

The researcher gives a few recommendations that focus on the methodological, theoretical, and practical points of view.

5.3.1 Methodological

It is recommended that a similar study should be conducted by soliciting views from mine owners or mine operators and mine workers from various mining companies in Malaysia including large- and small-scale mining operations. The inclusion of both top management and mine workers will enable researchers to get general and solid views from them with regard to the factors that influence safety culture practises in Malaysia. The development of the safety culture framework in the current study was purely obtained as a result of the involvement of 58 respondents, which consisted of mining experts, government agencies, and academicians. Therefore, it is recommended that there is involvement of various government agencies which directly deals with mining activities, such as Pejabat Tanah dan Galian (PTG), Perbadanan Menteri Besar Kelantan (PMBK), Perak Menteri Besar Incorporated (MB Inc), and NIOSH. Furthermore, the participation of various mining companies is also welcome. Thus, their experiences and opinions can be obtained collectively to understand influencing factors of safety culture practises at mining companies. Moreover, the safety culture questionnaire survey constructed by the researcher can be modified and used to investigate or assess the safety culture practises at a mining company. Moreover, the factors obtained can be analysed by various software and are not restricted to AHP since various analysis techniques are available nowadays in order to get better results.

5.3.2 Theoretical

The theoretical knowledge on factors contribute to safety culture from LR and SLR is slightly different from the findings of the current study. Based on the SLR, the behavioural dimension *("What people do")* greatly influenced the formation of safety culture in the mining industry. However, based on the current study, situational dimension *("What organisation has")* was the greatest influence on the formation of safety culture in the Malaysian mining industry. In conjunction with the experts' knowledge obtained through the Delphi study, 24 factors were identified for mining companies in Malaysia. All these factors were obtained by consensus and validated. Therefore, it is recommended to acknowledge the safety culture framework, such as using the safety culture questionnaire survey constructed by researchers, and recommend all mining companies perform their own safety culture assessment to assess their own safety culture practises. Therefore, it could help the mining companies identify and recognise which factor needs improvement based on the safety culture framework, which consists of 24 factors. Thus, it could help mining companies reduce the occurrence of mining accidents and incidents, which have big impact on their mining operations and activities.

5.3.3 Practical and Policy Implication

The following policy implications and practical recommendations have been identified:

i. The policy implication suggests that safety culture frameworks can be improved through mining companies' adherence to the core principles of the safety culture itself.

ii. Stakeholders responsible for mining activities should adopt effective management strategies to encourage all mining companies to implement a safety culture.

iii. A future safety culture framework in the Malaysian mining industry should contain the 24 factors.

iv. Planning, organising, monitoring, measuring, and controlling safety culture practises at mining companies would be feasible if the stakeholders were aware of the influencing factors, as suggested in the safety culture framework.

5.4 Limitations

Interesting and valuable findings have emerged from this study. However, the following limitations regarding the current study should be considered. The research was only conducted among mining experts, government agencies, and academicians who have extensive experience in the mining industry. It would be preferable to conduct a similar research study among mine owners or operators and mine workers from various mining companies in Malaysia, including large- and small-scale mining operations.

5.5 Recommendations for Further Research

The following suggestions for further studies have been identified:

i. The sequential mixed method approach was used in this study, and maybe in the future other methods can be applied to investigate safety culture factors in the mining industry in Malaysia.

ii. The number of participants in the Delphi study was small. Even though the 21 volunteered participants were enough for the Delphi study as suggested by previous literature, it was recommended to gather more experts in mining to get a better understanding of the influencing factors of safety culture in Malaysia and how the framework can be improved in the future.

iii. The safety practises and safety culture in the organisation of each mining company are unique. Therefore, the validated framework cannot be generalised to all mining companies. However, the framework can be a guide and an eye-opener for other mining companies to conduct their own safety culture assessments to investigate the safety culture practises among mine workers. Thus, top management can make improvements for the betterment of mining operations and management in the future.

5.6 Conclusion

A *Safety Culture Framework for the Mining Industry in Malaysia* was developed based on the mixed-method approach and consists of SLR, Preliminary Study, Delphi I, Delphi II, AHP study, FGD, and a case study at a volunteered mining company.

The results of this study have theoretical, methodological, and policy (practical) value because the respondents for the Delphi study were drawn from mining experts who have extensive experience in the mining industry, government sectors (enforcers and officers), and academicians (professors and senior lecturers). The respondents for the questionnaire survey were among the top management of mining companies. Furthermore, the respondents had a good working knowledge of the studied environment. In addition, the questionnaire survey tools for Delphi and AHP were validated by validators. The findings were then validated by FGD panel experts. Hence, it is considered that the presented safety culture frameworks maintain their validity. The result of the study provided information that can inform government agencies such as JMG and DOSH, the Malaysian Chamber of Mines, mining consultant firms, and individual mining companies, whether large- or small-scale mining operations, as they plan for and implement a safety culture.

Secondly, the study provides influencing factors for safety culture that will serve as a baseline for implementing safety culture practises at mining companies. The safety culture framework for the Malaysian mining industry that has been developed in this study will provide a reference for researchers who will study safety culture in the mining industry in the near future.

Moreover, the current study utilises the Analytical Hierarchy Process (AHP) to prioritise the influencing factors of safety culture. By adopting this methodology, the current study was able to prioritise and identify the most critical factors that are significant to constructing a safety culture in the mining industry in Malaysia. The practical implication is that the safety culture framework for the Malaysian mining industry can be enhanced by adopting the top five critical factors, which consist of (i) safety attitude, (ii) leadership of mine owners, (iii) enforcement of safety rules, (iv) safety awareness, and (v) reward and punishments, as well as other factors in the framework.

The validation of the safety culture framework by mining experts in FGD and the case study also showed the framework is significant to the Malaysian mining industry. Moreover, mine owners or mine operators, and other stakeholders responsible for mining projects in Malaysia can adopt this safety culture framework to improve safety culture awareness and practises in the Malaysian mining industry. In the future, all mining companies managing mining projects should adopt the 24 safety culture factors obtained from this study that are relevant to them in order to enhance the quality of the safety culture practises to prevent mining disasters, as well as to produce responsible miners in Malaysia.

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APPENDICES

Appendix A: Consent Form for Preliminary Study (Example)

CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

Title: Safety Culture Framework in Mining Industry in Malaysia
PhD Candidate: Siti Noraishah Ismail (PTS20005)
Institution: Universiti Malaysia Pahang

INFORMATION TO PARTICIPANTS:

We invite you to be a part of a study to investigate the influencing factors of safety culture in mining industry in Malaysia. The research requests your assistance because your expert views in mining activities could helpful to gain a picture of how safety culture is experienced and understood in mining industry. The results of this study are expected to provide relevant implications and recommendations for mining industry to improve their safety aspects especially in safety culture at workplace.

Certification by Participants

- I confirm that my participation in this research project is voluntary.
- I acknowledge that I will not be receiving any payments in regard to my participation
- I acknowledge that I have the right to decline or discontinue my participation in this research when I have a valid reason to do so.
- I have read and understood what the research is all about and how it will affect the target audience.
- I understand that the researchers will not identify me by name in any reports using information captured from one of my interviews or answers to the surveys I completed
- I understand that the researchers will not identify me by name and will publish her materials for research purposes only such as in thesis, journals, articles or other research-related projects

Participant's Name: Fatimah binti Sulaiman

Date: 29 March 2021

Appendix B: Email invitation for Subject Matter Experts in Preliminary study (Example)

Universiti Malaysia PAHANG

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my>

JEMPUTAN SEBAGAI EXPERT PANEL DI DALAM BIDANG PERLOMBONGAN BAGI MELENGKAPI BIDANG KAJIAN DOKTOR FALSAFAH

1 message

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my> Tue, Nov 3, 2020 at 10:19 AM
To: shukeri ismail <shukeri69@gmail.com>

Assalamualaikum wbt Tuan Hj. Shukeri,

Merujuk kepada perkara di atas, saya Siti Noraishah Ismail, pensyarah di Fakulti Teknologi Kejuruteraan Kimia dan Proses (FTKKP), Universiti Malaysia Pahang ingin menjemput Dr secara sukarela sebagai *Expert Panel* di dalam bidang kajian Doktor Falsafah saya. Berikut adalah maklumat berkenaan kajian saya;

Bidang Kajian : Occupational Safety and Health (OSH)

Tajuk Kajian : A Framework of Intrinsic Safety Method and Safety Culture for Mining Industry in Malaysia by applying an Analytical Hierarchy Process (AHP) Model

Penyelia Utama : Ts. Dr. Azizan Ramli (UMP)

Secara umumnya, tujuan kajian saya adalah untuk mengkaji amalan dan budaya keselamatan (*safety culture)* di dalam bidang perlombongan di Malaysia serta faktor-faktor yang mempengaruhinya. Kajian ini melibatkan pengumpulan maklumat dan pandangan daripada pihak penguatkuasa, pihak industri, pelombong dll.

Justeru, kajian ini dijalankan dengan mengambil kira pandangan dan input daripada pihak Tuan yang sangat berpengalaman serta banyak berjasa di dalam pembangunan bidang perlombongan di Malaysia. Sesi temubual secara atas talian (*1-2hour online interview session*) dan borang soal selidik (*questionnaire*) akan dijalankan sekiranya pihak Tuan bersetuju sebagai secara sukarela sebagai *Expert Panel.*

Mohon kerjasama Tuan untuk membalas emel ini sebelum 13 November 2020. Segala perhatian Tuan saya sertai dengan ucapan ribuan terima kasih.

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Best regards,

SITI NORAISHAH ISMAIL
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Faculty of Chemical & Natural Resources Engineering
Universiti Malaysia Pahang
Lebuhraya Tun Razak,26300 Kuantan,
Pahang, Malaysia.
Tel:095492832
HP No. 0177598834
Website : http://fkksa.ump.edu.my/index.php/en/

Appendix C: Appointment letters for Preliminary Study

Universiti Malaysia PAHANG

Fakulti Sains & Teknologi Industri
Faculty of Industrial Sciences & Technology

Universiti Malaysia Pahang
Lebuhraya Tun Razak
26300 Gambang, Kuantan
Pahang Darul Makmur
Tel. : +609 549 2765
Faks : +609 549 2766

Rujukan Kami : UMP.17.04/13.11/1/7 ( )
Tarikh : March 24, 2021

PUAN FATIMAH BINTI SULAIMAN
Pegawai Keselamatan & Kesihatan
SARAWAK COAL RESOURCES SDN. BHD.
(A SUBSIDIARY OF THE STATE GOVERNMENT OF SARAWAK)
Ground 1st and 2nd floor, SL 1181, Lot 1963, Block 68
Mukah New Township Extension
Jalan Orang Kaya Setia Raja
96400 Mukah, Sarawak

Puan,

LANTIKAN SEBAGAI PAKAR BIDANG OSH SECARA SUKARELA BAGI KEPERLUAN KAJIAN DOKTOR FALSAFAH (PHD)

NAMA PELAJAR	:	**SITI NORAISHAH BINTI ISMAIL**
ID PELAJAR	:	**PTS20005**
BIDANG KAJIAN	:	**OCCUPATIONAL SAFETY AND HEALTH (OSH)**
TAJUK KAJIAN	:	**SAFETY CULTURE FRAMEWORK FOR MINING INDUSTRY IN MALAYSIA**
PENYELIA UTAMA	:	**TS. DR. AZIZAN RAMLI**

Dengan hormatnya perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa pelajar di atas sedang mengikuti program Ijazah Doktor Falsafah (Ph.D) dalam bidang berkaitan di Fakulti Sains dan Teknologi Industri, Universiti Malaysia Pahang. Justeru itu, bagi tujuan kajian beliau, pihak pengurusan fakulti ingin melantik puan sebagai Pakar Bidang OSH di dalam kajian soal selidik / sesi temubual berkaitan *safety culture* sebagai memenuhi keperluan kajian pelajar. Semoga hasil kaji selidik / temubual yang diperolehi akan dapat membantu pelajar mencapai objektif projek beliau.

3. Sekiranya pihak puan memerlukan maklumat lebih lanjut, sila hubungi pelajar, Saudari Siti Noraishah binti Ismail ditalian 017-7598834 atau di alamat e-mel snoraishah@ump.edu.my. Kerjasama daripada pihak puan amatlah dihargai dan diucapkan jutaan terima kasih.

Sekian, terima kasih.

"PRIHATIN RAKYAT : DARURAT MEMERANGI COVID-19"

"BERKHIDMAT UNTUK NEGARA"
"Memasyarakatkan Teknologi"

Saya yang menjalankan amanah,

PROF. MADYA DR. MOHD HASBI BIN AB RAHIM
Dekan
Fakulti Sains dan Teknologi Industri
Universiti Malaysia Pahang
☎ :+609-5492767 Faks :+609-5492766

s.k. Ts. Dr. Azizan Bin Ramli (Penyelia Utama)

AA/Surat/Pengajian Siswazah/Rekod Pelajar

5-Star World Class Technological University
www.ump.edu.my

Appendix D: Preliminary study (Open-ended interview Question)

1) How can the safety culture be defined in general?
2) Have you heard about safety culture in mining industry? Which safety cultures are practiced in the mining industry as stipulated by the government?
3) In your opinion, how does poor safety culture can cause the mining accidents in Malaysia?
4) How would you define the safety culture in mining organization/company?
5) How would you define the safety culture's awareness in mining organization? Tell me about the last safety culture event/ programme/training/ your company organized.
6) Have you ever carried out a Safety Culture survey before? If yes, how was the survey carried out and how were the results presented?
7) Based on your experience, what are the important factors affecting the safety culture practices in mining organization?
8) In your opinion, what are characteristics of a leader/mine owner should have to foster safety culture in organization?
9) What are the benefits of safety culture practices in mining industry?
10) In your opinion, what are the challenges to promote safety culture practices in mining industry in Malaysia?

Appendix E: Consent Form for Delphi I and II Study (Example)

Thursday, June 24, 2021

CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

Title: Safety Culture Framework in Mining Industry in Malaysia
PhD Candidate: Siti Noraishah Ismail (PTS20005)
Institution: Universiti Malaysia Pahang

INFORMATION TO PARTICIPANTS:
We invite you to be a part of a study to investigate the influencing factors of safety culture in mining industry in Malaysia. The research requests your assistance because your expert views in mining activities could helpful to gain a picture of how safety culture is experienced and understood in mining industry. The results of this study are expected to provide relevant implications and recommendations for mining industry to improve their safety aspects especially in safety culture at workplace.

Certification by Participants

- I confirm that my participation in this research project is voluntary.
- I acknowledge that I will not be receiving any payments in regard to my participation.
- I confirm that the duration of the research wherein I will participate is 1-2 hours only which includes recorded interviews (held in April/May 2021) and completing surveys (in June 2021).
- I acknowledge that I have the right to decline or discontinue my participation in this research when I have a valid reason to do so.
- I have read and understood what the research is all about and how it will affect the target audience.
- I understand that the researchers will not identify me by name in any reports using information captured from one of my interviews or answers to the surveys I completed.

Participant Information

Participant's Name	sharizal samsudin
Age	48
Phone Number	(019) 955-7548

1

Email	sharizal@dhu.edu.my
Participant's Signature	
Date Signed	Friday, June 25, 2021

Thank you for your participation.

Any queries about your participation in this project may be directed to me at 017-7598834 ; snoraishah@ump.edu.my or my supervisor; Ts.Dr.Azizan Ramli at azizanramli@ump.edu.my

Appendix F: Email invitation for Delphi Technique 1st round (Example)

6/30/2021 Universiti Malaysia Pahang Mail - Jemputan Sebagai Pakar Bidang OSH Secara Sukarela Untuk Kajian "Safety Culture Framework f…

Universiti Malaysia PAHANG

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my>

Jemputan Sebagai Pakar Bidang OSH Secara Sukarela Untuk Kajian "Safety Culture Framework for Mining Industry in Malaysia"

1 message

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my> Tue, May 4, 2021 at 12:19 AM
To: shamsul8813@yahoo.com

Assalamualaikum wbt Tuan,

Merujuk kepada perkara di atas, saya Siti Noraishah Ismail, pensyarah dan juga pelajar PhD di Universiti Malaysia Pahang ingin menjemput pihak Tuan, secara sukarela sebagai pakar bidang OSH di dalam bidang kajian Doktor Falsafah saya. Tajuk kajian saya adalah "Safety Culture Framework for Mining Industry in Malaysia"

Secara umumnya, tujuan kajian saya adalah untuk mengkaji amalan dan budaya keselamatan (*safety culture)* di dalam bidang perlombongan di Malaysia serta faktor-faktor yang mempengaruhinya. Salah satu aspek kajian saya adalah mendapatkan maklumat dan pandangan daripada penguatkuasa, pihak industri, ahli akademik, pemilik lombong, pelombong, NGO dan lain-lain lagi. Kaedah penyeldikan kajian ini adalah seperti sesi soal selidik.

Justeru, saya ingin menjemput Tuan di dalam kajian berkaitan safety culture selaku wakil industri. Pengalaman Tuan amat saya hargai di dalam kajian saya.

Saya lampirkan **Participant Information Sheet** untuk makluman Tuan. Surat rasmi akan dikeluarkan sekiranya Tuan bersetuju dengan jemputan ini. Segala perhatian pihak Tuan saya ucapkan ribuan terima kasih.

Best regards,

SITI NORAISHAH ISMAIL
Lecturer
Faculty of Chemical and Process Engineering Technology
Universiti Malaysia Pahang
Lebuhraya Tun Razak,26300 Kuantan,
Pahang, Malaysia.
Tel:095492832
HP No. 0177598834
Website : http://fkksa.ump.edu.my/index.php/en/

Participant information sheet for Study Round 1 Delphi Technique.pdf
74K

Appendix G: Appointment letters for Delphi I Experts (Example)

Universiti Malaysia PAHANG

Fakulti Sains & Teknologi Industri
Faculty of Industrial Sciences & Technology

Universiti Malaysia Pahang
Lebuhraya Tun Razak
26300 Gambang, Kuantan
Pahang Darul Makmur
Tel. : +609 549 2765
Faks : +609 549 2766

Rujukan Kami : UMP.17.04/13.11/1/7 ( )
Tarikh : March 24, 2021

ENCIK MUHAMMAD FAIZAL BIN ZAINAL ABIDIN
Ketua Seksyen
Seksyen Penguatkuasaan
Jabatan Keselamatan dan Kesihatan Pahang (DOSH/JKKP)
Wisma PERKESO, Tingkat 2, Jalan Mat Kilau
25000 Kuantan, Pahang

Tuan,

LANTIKAN SEBAGAI PAKAR BIDANG OSH SECARA SUKARELA BAGI KEPERLUAN KAJIAN DOKTOR FALSAFAH (PHD)

NAMA PELAJAR	:	**SITI NORAISHAH BINTI ISMAIL**
ID PELAJAR	:	**PTS20005**
BIDANG KAJIAN	:	**OCCUPATIONAL SAFETY AND HEALTH (OSH)**
TAJUK KAJIAN	:	**SAFETY CULTURE FRAMEWORK FOR MINING INDUSTRY IN MALAYSIA**
PENYELIA UTAMA	:	**TS. DR. AZIZAN RAMLI**

Dengan hormatnya perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa pelajar di atas sedang mengikuti program Ijazah Doktor Falsafah (Ph.D) dalam bidang berkaitan di Fakulti Sains dan Teknologi Industri, Universiti Malaysia Pahang. Justeru itu, bagi tujuan kajian beliau, pihak pengurusan fakulti ingin melantik tuan sebagai Pakar Bidang OSH di dalam kajian soal selidik / sesi temubual berkaitan *safety culture* sebagai memenuhi keperluan kajian pelajar. Semoga hasil kaji selidik / temubual yang diperolehi akan dapat membantu pelajar mencapai objektif projek beliau.

3. Sekiranya pihak tuan memerlukan maklumat lebih lanjut, sila hubungi pelajar, Saudari Siti Noraishah binti Ismail ditalian 017-7598834 atau di alamat e-mel snoraishah@ump.edu.my. Kerjasama daripada pihak tuan amatlah dihargai dan diucapkan jutaan terima kasih.

Sekian, terima kasih.

"PRIHATIN RAKYAT : DARURAT MEMERANGI COVID-19"

"BERKHIDMAT UNTUK NEGARA"
"Memasyarakatkan Teknologi"

Saya yang menjalankan amanah,

PROF. MADYA DR. MOHD HASBI BIN AB RAHIM
Dekan
Fakulti Sains dan Teknologi Industri
Universiti Malaysia Pahang
☎ :+609-5492767 Faks :+609-5492766

s.k. Ts. Dr. Azizan Bin Ramli (Penyelia Utama)

AA/Surat/Pengajian Siswazah

5-Star World Class Technological University
www.ump.edu.my

Appendix H: Participant Information Sheet for Delphi 1st Round

Title: Safety Culture Framework in Mining Industry in Malaysia

Researcher Info;
Siti Noraishah Ismail – PhD Candidate
Faculty of Industrial Science and Technology
Universiti Malaysia Pahang
Lebuhraya Tun Razak,
26300 Gambang, Kuantan,Pahang
Email: snoraishah@ump.edu.my
HP no: 017-7598834

A. DESCRIPTION

This open-ended interview is being undertaken as part of my PhD research. The purpose of this research is to explore individual's experience of safety culture in the mining company with a view to identify the key influencing factors in creating and maintaining a positive safety culture, and providing guidelines on what sorts of programmes or other interventions might be useful for this.

The research requests your assistance because your expert views in mining activities could helpful to gain a picture of how safety culture is experienced and understood in mining industry. Moreover, knowledge in safety issue, organizational culture, industrial psychology also is welcomed in this research. The information gained in this early stage of the research will inform the direction of the rest of the PhD research.

B. PARTICIPATION

Your participation in this research is voluntary. If you do not agree to participate, you can withdraw from participation during the research without comment or penalty.

Your participation will involve an interview that will take approximately 45 minutes of your time. The interview will include questions around your views on what safety culture is and the factors that contribute to a positive safety culture. (An example question is "In your opinion, what are the key factors that contribute to a positive safety culture?"). You will be invited to participate in the interview via email, online platform (Google meet/ Zoom) or over the phone. Your contact details will be retained for the purpose of inviting you to participate in a follow-up round.

You will be contacted again in a few weeks via email to be invited to participate in a follow-up round that will include a questionnaire. Your participation in this follow-up round will also be voluntary. Your contact details will not be used for any other purpose and will not be retained once the study is completed.

The tentative schedule for 1st and 2nd round research is as follow;
1st round: open ended interview (10 April- 25 April 2021)
2nd round: questionnaire (20 May- 1 June 2021)

C. EXPECTED BENEFITS

It is expected that this research may not directly benefit you in the short term. However, it may benefit you indirectly through the development of guidelines or framework to assist in improving safety culture programmes and initiatives and potentially safety outcomes in your workplace.

D. RISKS

The risks associated with your participation in this research are considered low.

E. CONFIDENTIALITY

All comments and responses will be treated confidentially and will be made anonymous when transcribed. Responses will be de-identified before results are analyzed. To ensure that we have adequately recorded your comments during the interview, I will report back to you to verify your comments prior to their inclusion in the analysis.

The interview may be recorded in order to capture the information accurately. These audio recordings will only be accessed by the research team, and will not be used for any other purpose. The recordings will be destroyed after the contents have been transcribed. It is possible to participate in the research without being recorded. Please indicate this preference prior to the commencement of the interview.
F. CONSENT TO PARTICIPATE
Due to the nature of the research prior to the commencement of the interview, the interviewer will ask you to provide your verbal consent to participate. In using verbal consent, we will not require recording of your name or any other identifying details.
G. QUESTIONS / FURTHER INFORMATION
Please contact me if you would like further information about the research.

Thank you for helping with this research. Please keep this sheet for your future reference .

Appendix I: Delphi 1st Round: Open-ended interview Question

Study Round 1 Delphi Technique- Open-Ended Interview Questions (10 April- 25 April 2021)

PART 1: PARTICIPANT'S BACKGROUND					
NAME OF INTERVIEWEE			**CONDUCTED BY**	SITI NORAISHAH ISMAIL	
INTERVIEW DATE		**INTERVIEW START TIME**		**INTERVIEW END TIME**	
POSITION TITLE			**COMPANY**		

PART 2: SAFETY CULTURE IN THE MINING ORGANIZATION
1) How would you define the safety culture in mining industry?
2) What is the current status of safety culture's awareness in mining organization?
3) In your opinion, how does poor safety culture can cause the mining accidents in Malaysia?
PART 3: INFLUENCING FACTORS OF SAFETY CULTURE IN MINING INDUSTRY
4) Based on your experience, how the **individual/personal factors** can contribute to a positive safety culture in mining industry?
5) How the **working environment** contribute to a positive safety culture in mining industry?
6) How **the behavioral factors** can contribute to a positive safety culture in mining industry?
7) What other factors contribute to create a good safety culture in mining industry?
8) What else could the mining company do to improve safety culture?
PART 4: BENEFITS AND CHALLENGES OF SAFETY CULTURE
9) What are the benefits of safety culture practices in mining industry?
10) In your opinion, what are the barriers in creating and maintaining a positive safety culture in mining industry?
COMMENTS/ SUGGESTIONS
Please provide any additional comments or suggestion on the research study.

Thank you for helping with this research.

Appendix J: Email invitation for Delphi Technique 2nd round with Participant Information Sheet

Universiti Malaysia PAHANG

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my>

Online Questionnaire on Safety Culture

1 message

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my> Thu, Jun 24, 2021 at 5:17 PM

To: shamsul Arif Harun <shamsul8813@yahoo.com>

Assalamualaikum wbt Mr.Shamsul,

Thank you for your participation during the interview last April 2021. I am Siti Noraishah Ismail, a PhD student of the Faculty of Industrial Science and Technology. I am supervised by Ts.Dr.Azizan bin Ramli.

The following influencing factors were raised during the interviews with mining experts as critical to the formation of a positive safety culture for the mining industry in Malaysia. Based on the previous interview responses, the factors have been organised into three categories:

A. Psychological Factors

B. Situational Factors

C. Behaviour Factors

The aim of this questionnaire is to investigate the influencing factors of safety culture in the mining industry in Malaysia for my doctoral study "Safety Culture Framework for Mining Industry in Malaysia". The research requests your assistance because your expert views in mining activities could help to gain a picture of how safety culture is experienced and understood in the mining industry. The results of this study are expected to provide relevant implications and recommendations for the mining industry to improve their safety aspects especially in safety culture at the workplace.

The data collected will be used for research purposes only. All the information provided in this questionnaire will be kept confidential. I recognise the value of your time and sincerely appreciate your opinions as they are critical to the success of this study to discover new understandings. If you agree to participate in my study, please complete this questionnaire. It will take you approximately 15-20 minutes.

Kindly please complete these following links before 10th July 2021.

1. Consent Form for Participants Involved in Research

Link: https://form.jotform.com/211712420286447

2. Online Questionnaire on Safety Culture

Link: https://form.jotform.com/211702027989459

I also attached the participation information sheet for your information. Thank you for your participation.

Best regards,

SITI NORAISHAH ISMAIL
Lecturer
Faculty of Chemical and Process Engineering Technology
Universiti Malaysia Pahang
Lebuhraya Tun Razak,26300 Kuantan,
Pahang, Malaysia.
Tel:095492832
HP No. 0177598834
Website : http://fkksa.ump.edu.my/index.php/en/

Participant information sheet for Online Questionnaire.pdf
72K

Participant Information Sheet for Study Round 2 Delphi Technique

Title: Safety Culture Framework in Mining Industry in Malaysia
Researcher Info; Siti Noraishah Ismail – PhD Candidate Faculty of Industrial Science and Technology Universiti Malaysia Pahang Lebuhraya Tun Razak, 26300 Gambang, Kuantan,Pahang Email: snoraishah@ump.edu.my HP no: 017-7598834
A. DESCRIPTION
This online questionnaire is being undertaken as part of my PhD research. The purpose of this research is to explore individual's experience of safety culture in the mining company with a view to identify the key influencing factors in creating and maintaining a positive safety culture, and providing guidelines on what sorts of programmes or other interventions might be useful for this. The following Influencing factors were raised during the interviews as critical to the formation a positive safety culture for mining company in Malaysia. Based on the previous interview responses, the factors have been organized into three categories: A. Psychological Factors B. Situational Factors C. Behaviour Factors The research requests your assistance because your expert views in mining activities could helpful to gain a picture of how safety culture is experienced and understood in mining industry. Moreover, knowledge in safety issue, organizational culture, industrial psychology also is welcomed in this research. The information gained in this early stage of the research will inform the direction of the rest of the PhD research.
B. PARTICIPATION
Your participation in this research is voluntary. If you do not agree to participate, you can withdraw from participation during the research without comment or penalty. The data collected will be used for research purposes only. All the information provided in this questionnaire will be kept confidential. I recognize the value of your time and sincerely appreciate your opinions as they are critical to the success of our study to discover new understandings. If you agree to participate in my study, please complete this questionnaire. It will take you approximately 15-20 minutes.
C. EXPECTED BENEFITS
It is expected that this research may not directly benefit you in the short term. However, it may benefit you indirectly through the development of guidelines or framework to assist in improving safety culture programmes and initiatives and potentially safety outcomes in your workplace.
D. RISKS
The risks associated with your participation in this research are considered low.
E. CONFIDENTIALITY
All comments and responses will be treated confidentially and will be made anonymous
F. CONSENT TO PARTICIPATE

The return of the completed survey is accepted as an indication of your consent to participate in this project.
G. QUESTIONS / FURTHER INFORMATION
Please contact me if you would like further information about the research.

Thank you for helping with this research. Please keep this sheet for your reference.

Appendix K: Delphi 2nd Round: Sample of Online Questionnaire on Safety Culture and Example of Respondents' Feedbacks

Online Questionnaire on Safety Culture

Assalamualaikum wbt

Thank you for your participation during the interview last April 2021. I am Siti Noraishah Ismail, a PhD student of the Faculty of Industrial Science and Technology. I am supervised by Ts.Dr.Azizan bin Ramli.

The following influencing factors were raised during the interviews with mining experts as critical to the formation of a positive safety culture for the mining industry in Malaysia. Based on the previous interview responses, the factors have been organised into three categories:

A. Psychological Factors
B. Situational Factors
C. Behaviour Factors

The aim of this questionnaire is to investigate the influencing factors of safety culture in the mining industry in Malaysia for my doctoral study *"Safety Culture Framework for Mining Industry in Malaysia".* The research requests your assistance because your expert views in mining activities could help to gain a picture of how safety culture is experienced and understood in the mining industry. The results of this study are expected to provide relevant implications and recommendations for the mining industry to improve their safety aspects especially in safety culture at the workplace.

The data collected will be used for research purposes only. All the information provided in this questionnaire will be kept confidential. I recognise the value of your time and sincerely appreciate your opinions as they are critical to the success of this study to discover new understandings. If you agree to participate in my study, please complete this questionnaire. It will take you approximately 15-20 minutes.

Kindly please complete these following links before 10th July 2021.

1. Consent Form for Participants Involved in Research

Link: https://form.jotform.com/211712420286447

2. Online Questionnaire on Safety Culture

Link: https://form.jotform.com/211702027989459

I also attached the participation information sheet for your information. Thank you for your participation.

Best regards,

SITI NORAISHAH ISMAIL
Lecturer/ PhD Candidate
Faculty of Chemical and Process Engineering Technology
Universiti Malaysia Pahang
Lebuhraya Tun Razak,26300 Kuantan,
Pahang, Malaysia.
Tel:095492832
HP No. 0177598834
Website : http://fkksa.ump.edu.my/index.php/en/

PSYCHOLOGICAL DIMENSION							
Factors	**No.**	**Question**	**Please circle a number**				
1. Management concern/ care on workers	1(i)	Top management able to identify and recognize the workers that work under pressure and have intention to take shortcuts about safety.	1	2	3	4	5
	1(ii)	Top Management concerns on mine workers involved in mining accidents or any injuries	1	2	3	4	5
	1(iii)	Top management alerts on worker's ability to identify the potential hazard and risk while handling machinery or performing the given task	1	2	3	4	5
	1(iv)	Top management concerns on the workers that affects or can affect the OH&S performance of company.	1	2	3	4	5
	1(v)	Top management listens and gives importance to my opinion for improving work safety.	1	2	3	4	5
	1(vi)	The safety of workers is a big priority with management where I work.	1	2	3	4	5
2. Safety Attitude	2(i)	I feel free to report safety violations where I work.	1	2	3	4	5
	2(ii)	Completing my work is more important than doing work in safe ways.	1	2	3	4	5
3. Job satisfaction	3(i)	Worker's satisfaction in performing the job is the main priority of top management.	1	2	3	4	5
4. Health issue	4(i)	Top management concerns and care on worker's health issue including mental health issue.	1	2	3	4	5
5. Peer influence	5(i)	My colleagues point out each other's deficiencies in a work safety.	1	2	3	4	5
	5(ii)	I alert my colleagues who act contrary to work safety rules,	1	2	3	4	5

SITUATIONAL DIMENSION							
Factors	**No.**	**Question**	**Please circle a number**				
1. Safety policy	1(i)	The established OH&S policy and OH&S objectives of the mining company is compliance with OSH legal requirement and others requirement set up by government.	1	2	3	4	5
	1(ii)	All workers understand and comply with the relevant OH&S policies/procedures, legal requirement and other requirement of company while performing their job	1	2	3	4	5
2. Safety Audit	2(i)	All the requirements and outcomes of OH&S management system, including the OH&S policy and OH&S objectives of company will undergo an internal audit	1	2	3	4	5
	2(ii)	All the requirements and outcomes of OH&S management system, including the OH&S policy and OH&S objectives of company will undergo an external audit.	1	2	3	4	5
	2(iii)	The audit results are well reported and shared to all level of management and workers	1	2	3	4	5
3. Safety rules	3(i)	Top Management provides a clear standard operating procedure (SOP) to workers in handling machinery and handling chemical.	1	2	3	4	5
	3(ii)	All workers use proper Personal Protective Equipment (PPE) while performing job (such as noise, working at height, handling chemical, use machine etc)	1	2	3	4	5
4. Competent SHO	4(i)	Providing a competent Safety and Health Officer in supporting the OH&S management system, including the OH&S policy and OH&S objectives.	1	2	3	4	5
5. Safety /education	5(i)	All workers are provided with the relevant training on OSH legal requirement and other requirement.	1	2	3	4	5
6.Safety programme	6(i)	All the safety programmes, activities or events are intended to support the OH&S policy and OH&S objectives of the mining company	1	2	3	4	5
7. Safety planning	7(i)	iTop Management responsible to take action in addressing	1	2	3	4	5

		nonconformities and continually improve its OH&S performance is important to construct safety culture.					
	7(ii)	Top Management responsible in identifying, solving and providing preventative action related to ergonomics problem facing by workers	1	2	3	4	5
	7(iii)	Top Management implement the engineering controls, reorganization of work, or both at workplace	1	2	3	4	5
8. Medical surveillance	8(i)	Top Management provides Occupational Health Doctor to handle health issues among worker including mental health issue	1	2	3	4	5
	8(ii)	Top Management provides annual medical check up to workers	1	2	3	4	5
9. Safety competency	9(i)	Top management consider the previous educational background of workers to create safety culture at current workplace	1	2	3	4	5
	9(ii)	Top management consider the previous working experience of worker to create a safety culture at current workplace	1	2	3	4	5
10. Safety signage	10(i)	Top management provides a clear safety signage at mine site and working area.	1	2	3	4	5

BEHAVIOUR DIMENSION							
Factors	**No.**	**Question**	**Please circle a number**				
1. Management action and responsibility	1(i)	Top Management committed to ensure each level of workers able to understand, apply and support the established OH&S policy and OH&S objectives of the company.	1	2	3	4	5
	1(ii)	The organization should examine the resources required (e.g. financial, human, equipment, infrastructure) to achieve OH&S policy and OH&S objectives of the company.	1	2	3	4	5
	1(iii)	The Top Management has allocation or budget to support the intended outcome of OH&S policy and OH&S objectives of the company	1	2	3	4	5
	1(iv)	Top Management shows the commitment by providing the resources needed for the establishment, implementation, maintenance and continual improvement of the OH&S management system.	1	2	3	4	5
	1(v)	Establishing a planned response to emergency situations, including the provision of first aid are not important in mining industry.	1	2	3	4	5
2. Safety communication	2(i)	The OH&S policy, objectives, requirement and information are well documented and easily accessed by workers	1	2	3	4	5
	2(ii)	Communicating relevant safety information to contractors, visitors, emergency response services, government authorities and the local community is important to create a safety culture.	1	2	3	4	5
	2(iii)	The dissemination and communication of OH&S information is consistent and reliable with information generated within the OH&S management system.	1	2	3	4	5

3. Leadership	3 (i)	Appointing competent Safety and Health Officer in supporting the OH&S management system, including the OH&S policy and OH&S objectives.	1	2	3	4	5
4. Safety training	4(i)	Top Management is committed to have competent workers by providing adequate and appropriate education and training.	1	2	3	4	5
	4(ii)	Determining competence requirements, training needs, training and evaluating training for workers are important to construct safety culture.	1	2	3	4	5
5. Safety awareness	5(i)	All workers give full commitment and comply with the relevant OH&S policies/procedures, legal requirement and other requirement of company while performing their job.	1	2	3	4	5
	5(ii)	Each level of workers is aware and have clear understanding on the OH&S policy and OH&S objectives of company.	1	2	3	4	5
	5(iii)	Workers are able to apply and comply relevant OSH legal requirement and other requirement to do their job.	1	2	3	4	5
	5(iv)	Does eliminate hazards and reduce OH&S risks are important for safety culture?	1	2	3	4	5
6. Safety reporting	6(i)	All incidents, non-compliance and non-conformity are investigated quickly in order to improve safety at the workplace as soon as possible. Preventive reports are recommended for future reference.	1	2	3	4	5
	6(ii)	Any safety concerns raised are treated with high urgency in mining organization.	1	2	3	4	5
	6(iii)	Improving the occupational health and safety culture, such as by extending competence related to occupational health and safety beyond	1	2	3	4	5

		requirements or encouraging workers to report incidents in a timely manner.					
7. Safety promotion	7(i)	Does safety activities or events are actively promoting safety culture in mining industry?	1	2	3	4	5
8. Enforcement on safety rules	8(i)	Does wearing proper Personal Protective Equipment (PPE) and understand the instructions to wear PPE are actively promoting safety culture in mining industry?	1	2	3	4	5
9. Reward and punishment	9(i)	Top Management acknowledge and reward the workers based on the contribution and commitment towards OH&S management system, including the benefits of improved OH&S performance of the company.	1	2	3	4	5

Thursday, June 24, 2021

Questionnaire on Influencing Factor of Safety Culture in Mining Industry

Dear participants,
I am Siti Noraishah Ismail, a PhD student of the Faculty of Industrial Science and Technology. I am supervised by Ts.Dr.Azizan bin Ramli.
The aim of this questionnaire is to investigate the influencing factors of safety culture in mining industry in Malaysia for my doctoral study "Safety Culture Framework for Mining Industry in Malaysia". The research requests your assistance because your expert views in mining activities could helpful to gain a picture of how safety culture is experienced and understood in mining industry. The results of this study are expected to provide relevant implications and recommendations for mining industry to improve their safety aspects especially in safety culture at workplace.
The following Influencing factors were raised during the interviews (last April/May 2021) as critical to the formation a positive safety culture for mining company in Malaysia. Based on the previous interview responses, the factors have been organised into three categories:

A. Psychological Factors (Care)
B. Organizational Factors (Compliance)
C. Behaviour Factors (Commitment)

The data collected will be used for research purposes only. All the information provided in this questionnaire will be kept confidential. I recognise the value of your time and sincerely appreciate your opinions as they are critical to the success of this study to discover new understandings. If you agree to participate in my study, please complete this questionnaire. It will take you approximately 15-20 minutes.

Thank you for your participation.
Sincerely,
Siti Noraishah Ismail, PhD Candidate,
Faculty of Industrial Science and Technology,
Universiti Malaysia Pahang

Name

Job Position

Years of working experience

The following items are required in constructing safety culture in mining industry. Rate and tick the appropriate box (one answer only) for each question based on your finding and perception. The questionnaire will use 5 to 1 scale: 5 = Strongly Agree,4=Agree, 3= Neutral, 2= Disagree, 1 = Strongly Disagree

	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
1. Top management concerns on the workers that affects or can affect the OH&S performance of company.		✓			
2. Top management alerts on worker's ability to identify the potential hazard and risk while handling machinery or performing the given task.			✓		
3. Top					

Appendix L: Invitation Email as a Validator for Questionnaire on Safety Culture

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my>

JEMPUTAN SEBAGAI VALIDATOR BORANG SOAL SELIDIK DI DALAM BIDANG PERLOMBONGAN BAGI MELENGKAPI BIDANG KAJIAN DOKTOR FALSAFAH

7 messages

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my> Mon, Mar 15, 2021 at 12:16 PM
To: redzuan_onn@venatorcorp.com

Assalamualaikum wbt Tuan,

Merujuk kepada perkara di atas, saya Siti Noraishah Ismail, pensyarah dan juga pelajar PhD di Universiti Malaysia Pahang ingin menjemput pihak Tuan secara sukarela sebagai *validator* di dalam bidang kajian Doktor Falsafah saya. Tajuk kajian saya adalah "Safety Culture Framework for Mining Industry in Malaysia"

Secara umumnya, tujuan kajian saya adalah untuk mengkaji amalan dan budaya keselamatan (*safety culture)* di dalam bidang perlombongan di Malaysia serta faktor-faktor yang mempengaruhinya. Salah satu aspek kajian saya adalah mendapatkan maklumat dan pandangan daripada penguatkuasa, agensi kerajaan, pihak industri, ahli akademik, pemilik lombong, pelombong, NGO dan lain-lain lagi. Kaedah penyeldikan kajian ini adalah seperti sesi temubual, soal selidik (Delphi Technique) dan menggunakan Analytical Hierarchy Process (AHP).

Justeru, saya ingin menjemput Tuan sebagai *validator* dan untuk borang soal selidik (questionnaire) berkaitan safety culture yang akan saya rangka. Sesi soal selidik dijangka akan dijalankan pada Jun 2021 nanti.

Pengalaman Tuan di dalam bidang OSH amat saya hargai. Surat rasmi akan dikeluarkan sekiranya bersetuju dengan jemputan ini. Mohon kerjasama pihak Tuan untuk membalas emel ini sebelum 25 Mac 2021 beserta CV terkini Tuan. Segala perhatian pihak Tuan saya ucapkan ribuan terima kasih.

Best regards,

SITI NORAISHAH ISMAIL
Lecturer/ PhD student
Faculty of Chemical and Process Engineering Technology
Universiti Malaysia Pahang
Lebuhraya Tun Razak,26300 Kuantan,
Pahang, Malaysia.
Tel:095492832
HP No. 0177598834
Website : http://fkksa.ump.edu.my/index.php/en/

Redzuan Onn <redzuan_onn@venatorcorp.com> Mon, Mar 15, 2021 at 5:15 PM
To: "SITI NORAISHAH BINTI ISMAIL ." <snoraishah@ump.edu.my>

Waalaikumsalam

Insya Allah saya akan beri kerjasama sebagai validator soal selidik thesis tersebut. Dilampirkan bersama CV saya seperti yang di minta.

Thanks & Best regards;

Redzuan Onn

EHS Superintendent

Venator Asia Sdn. Bhd, Teluk Kalung Industrial Area, 24007, Kemaman, Terengganu, Malaysia

Tel : +609-8628789 Fax : +609-8631988 Mobile : +6012-8282593

redzuan_onn@venatorcorp.com

www.venatorcorp.com

Appendix M: Appointment Letter as Validator for Questionnaire on Safety Culture

Universiti Malaysia PAHANG

Fakulti Sains & Teknologi Industri
Faculty of Industrial Sciences & Technology

Universiti Malaysia Pahang
Lebuhraya Tun Razak
26300 Gambang, Kuantan
Pahang Darul Makmur
Tel. : +609 549 2765
Faks : +609 549 2766

Rujukan Kami : UMP.17.04/13.11/1/7 (   )
Tarikh : 10 Disember 2021

ENCIK REDZUAN ONN
EHS Superintendent
Venator Asia Sdn. Bhd.
Teluk Kalung Industrial Area
24007 Kemaman, Terengganu

Tuan,

LANTIKAN SEBAGAI PANEL PENILAI KESAHAN ALAT UKUR INSTRUMEN KAJIAN PHD MENGGUNAKAN TEKNIK DELPHI (SOALAN KAJI SELIDIK)

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa pelajar berikut sedang mengikuti program Ijazah Doktor Falsafah (Ph.D) di Fakulti Sains dan Teknologi Industri (FSTI), Universiti Malaysia Pahang:

Nama Pelajar	:	**Siti Noraishah Binti Ismail**
No. Matrik	:	**PTS20005**
Bidang Kajian	:	**Keselamatan dan Kesihatan Pekerjaan**
Nama Penyelia	:	**Ts. Dr. Azizan Bin Ramli**
Tajuk Kajian	:	***Safety Culture Framework for Mining Industry in Malaysia***

3. Justeru itu, pihak pengurusan fakulti ingin melantik tuan sebagai Panel Penilai bagi memastikan instrumen yang disediakan dalam soal selidik dan kajian pelajar adalah menepati objektif kajian tersebut. Sumbangan dan khidmat kepakaran tuan diharapkan dapat membantu pelajar dalam penyelidikan berkenaan (sila rujuk Lampiran 1). Sekiranya terdapat sebarang pertanyaan, pihak tuan boleh menghubungi saudari Siti Noraishah binti Ismail di talian 017-7598834 atau di alamat e-mel snoraishah@ump.edu.my.

Segala kerjasama dan perhatian tuan berhubung perkara ini amatlah dihargai dan diucapkan jutaan terima kasih.

"BERKHIDMAT UNTUK NEGARA"
"Memasyarakatkan Teknologi"

Saya yang menjalankan amanah,

TS. DR. SAIFFUL KAMALUDDIN BIN MUZAKIR @ LOKMAN
Dekan
Fakulti Sains dan Teknologi Industri
☎ :+609-5492767 Faks :+609-5492766

AA/Surat/Pengajian Siswazah/Rekod Pelajar

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Appendix N: Validation Form for Delphi 2nd Round: Online Questionnaire on Safety Culture

VALIDATION FORM

INFLUENCING FACTORS FOR POSITIVE SAFETY CULTURE QUESTIONNAIRE (ONLINE)

Validator Info

Name : Redzuan B. Onn

Job Position : EHS Superintendent

Years of Experience : 17 Years

Target of respondents: Mining expert with mining experience (mine owner, mine operator, top management in mining, mining consultant, government agencies, Safety Health Officer, academician)

No.	Item	Scale				
1.	**Clarity and Directions of Items.** The vocabulary level, language, structure and conceptual level of participants. The test directions and the items are written in a clear and understandable manner	5	4	3	2	1
2.	**Presentation and Organization of Items.** The items are presented and organized in logical manner.	5	4	3	2	1
3.	**Suitability of Items.** The item appropriately presented the substance of the research. The questions are designed to determine the skills that are supposed to be measured.	5	4	3	2	1
4.	**Adequateness of the Content.** The number of the questions per area is a representative enough of all the questions needed for the research.	5	4	3	2	1
5.	**Attainment of Purpose.** The instrument as a whole fulfils the objectives needed for the research.	5	4	3	2	1
6.	**Objective.** Each item question requires only one specific answer or measures	5	4	3	2	1
7.	**Scale and Evaluation Rating.** The scale adapted is appropriate for them.	5	4	3	2	1

Remarks: All questionnaires are fair and relevant to the scope of research.

Signature Over Printed Name

VALIDATION FORM

QUESTIONNAIRE ON THE INFLUENCING FACTORS OF SAFETY CULTURE

Validator Info

Name : Mohamad Aliasman Morshidi

Job Position : OSH Consultant & Trainer

Years of Experience : 23 years

Target of respondents: Mining expert with mining experience (mine owner, mine operator, top management in mining, mining consultant, government agencies, Safety Health Officer, academician)

No.	Item	Scale				
1.	**Clarity and Directions of Items.** The vocabulary level, language, structure and conceptual level of participants. The test directions and the items are written in a clear and understandable manner	5	4	3	2	1
2.	**Presentation and Organization of Items.** The items are presented and organized in logical manner.	5	4	3	2	1
3.	**Suitability of Items.** The item appropriately presented the substance of the research. The questions are designed to determine the skills that are supposed to be measured.	5	4	3	2	1
4.	**Adequateness of the Content.** The number of the questions per area is a representative enough of all the questions needed for the research.	5	4	3	2	1
5.	**Attainment of Purpose.** The instrument as a whole fulfils the objectives needed for the research.	5	4	3	2	1
6.	**Objective.** Each item question require only one specific answer or measures	5	4	3	2	1
7.	**Scale and Evaluation Rating.** The scale adapted is appropriate for them.	5	4	3	2	1

Remarks: 1. Ensure the questions are focusing and accurate in the right context of the subjects that you want to ask. For example, questions related to Psychological Factors should related to the "feeling of the person" towards OSH matters at the workplace.

2. Consistency of the question in terms of statement or question approach. For example Question B16 & B17.

Signature Over Printed Name

VALIDATION FORM

INFLUENCING FACTORS FOR POSITIVE SAFETY CULTURE QUESTIONNAIRE (ONLINE)

Validator Info

Name : **SHAH ROLLAH ABDUL WAHAB**

Job Position : **SENIOR LECTURER**

Years of Experience : **19**

Target of respondents: Mining expert with mining experience (mine owner, mine operator, top management in mining, mining consultant, government agencies, Safety Health Officer, academician)

No.	Item	Scale				
1.	**Clarity and Directions of Items.** The vocabulary level, language, structure and conceptual level of participants. The test directions and the items are written in a clear and understandable manner	5	**4**	3	2	1
2.	**Presentation and Organization of Items.** The items are presented and organized in logical manner.	5	**4**	3	2	1
3.	**Suitability of Items.** The item appropriately presented the substance of the research. The questions are designed to determine the skills that are supposed to be measured.	5	**4**	3	2	1
4.	**Adequateness of the Content.** The number of the questions per area is a representative enough of all the questions needed for the research.	**5**	4	3	2	1
5.	**Attainment of Purpose.** The instrument as a whole fulfils the objectives needed for the research.	**5**	4	3	2	1
6.	**Objective.** Each item question requires only one specific answer or measures	**5**	4	3	2	1
7.	**Scale and Evaluation Rating.** The scale adapted is appropriate for them.	**5**	4	3	2	1

Remarks:

It is advisable for the researcher to look at these matters:

1) The operationalization of all categories especially 'what organisation has done' and 'what people do'.
2) Simplify statements used in the questionnaire by restructuring the statement or giving an example.
3) Avoid any term/statement that may disgrace the respondents' background such as educational background (refer to my comments on the attached questionnaire)
4) Conduct exploratory factor analysis (EFA) to confirm the suitability of items/statements to its categories

I wish you all the best for your research

DR. SHAH ROLLAH BIN ABDUL WAHAB
Senior Lecturer
Department of Human Resource Development
School of Human Resource Development and Psychology
Faculty of Social Sciences and Humanities
Universiti Teknologi Malaysia
81310 Skudai, Johor, Malaysia

Signature Over Printed Name

Appendix O: Email invitation for Experts in AHP

اونيۏرسيتي مليسيا ڤهڠ
UNIVERSITI MALAYSIA PAHANG

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my>

AHP Questionnaire Survey

3 messages

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my> Mon, Sep 20, 2021 at 3:56 PM
To: tan@jresources.com, Tan L T <LAITEE6@hotmail.com>

Dear Madam Tan,

Thank you for accepting to participate in this survey. This online questionnaire using AHP approach is being undertaken as part of my PhD research. The purpose of this research is to evaluate the key influencing factors in creating a safety culture framework for the mining industry in Malaysia.

I have attached the (1) Participant information sheet, (2) Consent letter form and (3) AHP Questionnaire survey to be completed before 10 October 2021.

Thank you again for your help.

--

Best regards,

SITI NORAISHAH ISMAIL
Lecturer
Faculty of Chemical and Process Engineering Technology
Universiti Malaysia Pahang
Lebuhraya Tun Razak,26300 Kuantan,
Pahang, Malaysia.
Tel:095492832
HP No. 0177598834
Website : http://fkksa.ump.edu.my/index.php/en/

Appendix P: Appointment letters for AHP Experts (Example)

Universiti Malaysia PAHANG

Fakulti Sains & Teknologi Industri
Faculty of Industrial Sciences & Technology

Universiti Malaysia Pahang
Lebuhraya Tun Razak
26300 Gambang, Kuantan
Pahang Darul Makmur
Tel. : +609 549 2765
Faks : +609 549 2766

Rujukan Kami : UMP.17.04/13.11/1/7 ( )
Tarikh : 8 Oktober 2021

PUAN TAN LAI TEE
Department Head of Mine Planning & Reporting
Specific Resources Sdn Bhd,
Empang Jaleh, Km8, Jalan Lipis Raub
27200 Kuala Lipis, Pahang.

Puan,

LANTIKAN SEBAGAI RESPONDEN SECARA SUKARELA BAGI KEPERLUAN KAJIAN DOKTOR FALSAFAH (PHD)

NAMA PELAJAR : SITI NORAISHAH BINTI ISMAIL
ID PELAJAR : PTS20005
BIDANG KAJIAN : OCCUPATIONAL SAFETY AND HEALTH (OSH)
TAJUK KAJIAN : SAFETY CULTURE FRAMEWORK FOR MINING INDUSTRY IN MALAYSIA
PENYELIA UTAMA : TS. DR. AZIZAN BIN RAMLI

Dengan hormatnya perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa pelajar di atas sedang mengikuti program Ijazah Doktor Falsafah (Ph.D) dalam bidang berkaitan di Fakulti Sains dan Teknologi Industri, Universiti Malaysia Pahang. Justeru itu, bagi tujuan kajian beliau, pihak pengurusan fakulti ingin melantik puan sebagai Responden di dalam kajian soal selidik berkaitan *safety culture* sebagai memenuhi keperluan kajian pelajar. Semoga hasil kaji selidik yang diperolehi akan dapat membantu pelajar mencapai objektif projek beliau.

3. Sekiranya pihak puan memerlukan maklumat lebih lanjut, sila hubungi pelajar, Saudari Siti Noraishah binti Ismail di talian 017-7598834 atau di alamat e-mel snoraishah@ump.edu.my. Kerjasama daripada pihak puan amatlah dihargai dan diucapkan jutaan terima kasih.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"
"*Memasyarakatkan Teknologi*"

Saya yang menjalankan amanah,

TS. DR. SAIFFUL KAMALUDDIN BIN MUZAKIR @ LOKMAN
Dekan
Fakulti Sains dan Teknologi Industri
Universiti Malaysia Pahang

s.k. Ts. Dr. Azizan Bin Ramli (Penyelia Utama)

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Appendix Q: Participants Information Sheet and Consent Form for AHP study (Example)

Title: Safety Culture Framework in Mining Industry in Malaysia
Researcher Info; Siti Noraishah Ismail – PhD Candidate Faculty of Industrial Science and Technology Universiti Malaysia Pahang Lebuhraya Tun Razak, 26300 Gambang, Kuantan,Pahang Email: snoraishah@ump.edu.my HP no: 017-7598834
A. DESCRIPTION
This online questionnaire using AHP approach is being undertaken as part of my PhD research. The purpose of this research is to evaluate the key influencing factors in creating safety culture framework for mining industry in Malaysia The following influencing factors in the questionnaire were gathered during the interviews with more than 20 mining experts previously. These influencing factors as critical to the formation a positive safety culture for mining company in Malaysia. Based on the previous interview responses, the factors have been organized into three categories: A. Psychological Dimension B. Situational Dimension C. Behaviour Dimension The influencing factors of for each dimension is attached in the questionnaire
B. PARTICIPATION
Your participation in this research is voluntary. If you do not agree to participate, you can withdraw from participation during the research without comment or penalty. The data collected will be used for research purposes only. All the information provided in this questionnaire will be kept confidential. I recognize the value of your time and sincerely appreciate your opinions as they are critical to the success of our study to discover new understandings. If you agree to participate in my study, please complete this questionnaire. It will take you approximately 30 minutes
C. EXPECTED BENEFITS
It is expected that this research may not directly benefit you in the short term. However, it may benefit you indirectly through the development of guidelines or framework to assist in improving safety culture programmes and initiatives and potentially safety outcomes in mining industry
D. RISKS
The risks associated with your participation in this research are considered low.
E. CONFIDENTIALITY
All comments and responses will be treated confidentially and will be made anonymous
F. CONSENT TO PARTICIPATE
The return of the completed survey is accepted as an indication of your consent to participate in this project.
G. QUESTIONS / FURTHER INFORMATION
Please contact me if you would like further information about the research.

Thank you for helping with this research. Please keep this sheet for your reference.

CONSENT FORM FOR PARTICIPANTS INVOLVED IN PHD RESEARCH

INFORMATION TO PARTICIPANTS:

We invite you to be a part of a study to investigate the influencing factors of safety culture in mining industry in Malaysia. The research requests your assistance because your expert views in mining activities could helpful to gain a picture of how safety culture is experienced and understood in mining industry. The results of this study are expected to provide relevant implications and recommendations for mining industry to improve their safety aspects especially in safety culture at workplace.

CERTIFICATION BY PARTICIPANT

I, ……Sharol Azuan Bin Zainuddin……………………from……Wullersdorf Resources Sdn Bhd……………,

certify that I am at least 18 years old and that I am voluntarily giving my consent to participate in the study "*Safety Culture Framework in Mining Industry in Malaysia*" being conducted at Universiti Malaysia Pahang (UMP) by PhD Candidate Siti Noraishah Ismail and supervised by Ts. Dr. Azizan Ramli.

I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by Madam Siti Noraishah Ismail and that I freely consent to participate and involve in the questionnaire survey using Analytical Hierarchy Process (AHP) method that tentatively will be held in September 2021.

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardize me in any way.

I have been informed that the information I provide will be kept confidential.

Signed : ______________

Date : 03 October 2021

Any queries about your participation in this project may be directed to me at 017-7598834 ; snoraishah@ump.edu.my or my supervisor; Ts.Dr.Azizan Ramli at azizanramli@ump.edu.my

Appendix R: AHP Questionnaire on Safety Culture

Part 1: Main Safety Culture Criteria																		
1.Psychological : Refer to the "How People Feel" for individual and group values, attitudes and perception about safety (Cooper, 2000) **2.Situational : Refer to "What Organizational Has" including policies, regulation, organizational structure and management systems (Cooper, 2000)** **3.Behaviour : Refer to "What People Do" such as safety related actions and behaviour, safety leadership (Cooper, 2000)**																		
Criteria A	**Left hand side (LHS) is more important than RHS**								**Equal**	**Right hand side (RHS) is more important than LHS**								**Criteria B**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Psychological	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Situational
Psychological	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Behavior
Situational	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Behaviour

Part 2: Evaluation of Sub Criteria of Safety Culture For Psychological Dimension																		
1.Management care on workers: Refers to management's interest with workers' psychological conditions as they relate to their work environment and performance. **2.Safety Attitude: Refers to mine workers' psychological attitudes regarding workplace safety culture, procedures, and accident prevention.** **3.Job satisfaction: Refers to a worker's satisfaction with the task he or she has been assigned without undermining the employer's efforts.** **4.Health of Worker: Refers to a worker's physical and mental ability to do the task at hand** **5.Peer influence: Refers to co-workers or colleagues who have a significant impact (good or bad) on the development of a workplace safety culture.**																		
Sub Criteria A	**Left hand side (LHS) is more important than RHS**								**Equal**	**Right hand side (RHS) is more important than LHS**								**Sub Criteria B**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Management care on workers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety Attitude
Management care on workers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Job Satisfaction
Management care on workers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Health of Worker
Management care on workers	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Peer influence
Safety Attitude	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Job Satisfaction
Safety Attitude	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Health of Worker
Safety Attitude	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Peer influence
Job Satisfaction	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Health of Worker

Job Satisfaction	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Peer influence
Health of Worker	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Peer influence

Part 3: Evaluation of Sub Criteria of Safety Culture For Situational Dimension

. No. Factors

1.Safety policy: Refers to the mining companies stated OH&S policy and OH&S objectives, which include compliance with OSH legal requirements and other government-imposed requirements.
2.Safety Audit: Refers to the auditor's internal and external audits, and ensure that all records are appropriately documented for future reference.
3.Safety rule: Refers to all of the mining company's developed standard operating procedures, guidelines, rules, regulations, and safety practices, which must be followed by all mine personnel and do not conflict with local authorities' and government's requirements.
4.Competent SHO: SHO who is well-trained and experienced in mining operations and activities is referred to as a competent SHO.
5.Safety education: Refers to any training offered by management to improve employees' safety skills and knowledge.
6.Safety programme: Refers to current and completed programmes, events, and activities such as safety awareness week, safety first, and others.
7.Safety planning: Refers to all short and long-term plans, as well as ongoing safety planning offered to employees by senior management. For future reference, everything forthcoming and completed planning must be carefully documented.
8.Medical surveillance: Top management assigns an Occupational Health Doctor to evaluate employee health and safety to ensure that employees are physically and psychologically capable of doing their duties.
9.Safety competency: Refers to employees' prior safety knowledge and work experience, as well as any ongoing safety training or education they get to improve their professional abilities and competences.
10.Safety signage: Refers to any chemical signage, working station signage, mining site signage, or safety promotion signage is used to keep personnel informed of impending dangers.

Sub Criteria A	**Left hand side (LHS) is more important than RHS**								**Equal**	**RHS (right hand side) is more important than LHS**								**Sub Criteria B**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Safety policy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety Audit
Safety policy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety rules
Safety policy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Competent SHO
Safety policy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety training
Safety policy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety program
Safety policy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety planning
Safety policy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Medical surveillance
Safety policy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety competency

Safety policy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety signage
Safety Audit	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety rules
Safety Audit	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Competent SHO
Safety Audit	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety training
Safety Audit	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety program
Safety Audit	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety planning
Safety Audit	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Medical surveillance
Safety Audit	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety competency
Safety Audit	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety signage
Safety rules	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Competent SHO
Safety rules	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety training
Safety rules	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety programme
Safety rules	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety planning
Safety rules	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Medical surveillance
Safety rules	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety competency
Safety rules	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety signage
Competent SHO	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety training
Competent SHO	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety programme
Competent SHO	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety planning
Competent SHO	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Medical surveillance
Competent SHO	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety competency
Competent SHO	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety signage
Safety training	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety programme
Safety training	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety planning
Safety training	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Medical surveillance
Safety training	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety competency

Safety training	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety signage
Safety programme	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety planning
Safety programme	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Medical surveillance
Safety programme	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety competency
Safety programme	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety signage
Safety planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Medical surveillance
Safety planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety competency
Safety planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety signage
Medical surveillance	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety competency
Medical surveillance	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety signage
Safety competency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety signage

Part 4: Evaluation of Sub Criteria of Safety Culture For Behavior Dimension

No. Factors

1. Management action and responsibility: Refer to top management's commitment to ensuring that all employees follow the company's safety policies and rules.
2.Safety communication: Refer to management's communication channels, such as email, memos, safety briefings, bulletin boards, reporting systems, and others, to guarantee dual communication between employees and employers.
3.Leadership: Refer to a well-trained and experienced SHO, supervisor who is capable of effectively leading and supervising personnel.
4.Safety training: Refers to management's commitment to offer staff with sufficient training and competence courses.
5.Safety awareness: Refers to employee knowledge of the significance of safety and the culture of safety at work, as well as comprehension of safety policies. Standard Operating Procedures (SOPs), standards, and regulations
6.Safety reporting: To report misbehavior or unethical concerns involving workers or supervisors, use the management-provided method, which may be used either offline (manually) or online.
7. Safety promotion: Any promotion, including activities and programmes created by management to instill a safety culture at work, such as safety week, safety film, safety signs, safety talk, and safety seminar and others
8.Enforcement on safety rules: Refer to the established SOP, regulations, and standards, which must be adhered to by all levels of personnel.
9. Reward and punishment: Refer to bonuses to reward excellent employees, or any misbehavior and unethical behavior by employees must be penalized.

Sub Criteria A	Left hand side (LHS) is more important than RHS								Equal	Right hand side (RHS) is more important than LHS								Sub Criteria B
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Management action and responsibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	. Safety communication
Management action and responsibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Leadership:
Management action and responsibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety training
Management action and responsibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety awareness
Management action and responsibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety reporting
Management action and responsibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety promotion
Management action and responsibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Enforcement on safety rules:
Management action and responsibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reward and punishment

. Safety communication	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Leadership
. Safety communication	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety training
. Safety communication	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety awareness
. Safety communication	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety reporting
. Safety communication	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety promotion
. Safety communication	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Enforcement on safety rules
. Safety communication	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reward and punishment
Leadership	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety training
Leadership	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety awareness
Leadership	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety reporting
Leadership	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety promotion
Leadership	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Enforcement on safety rules
Leadership	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reward and punishment
Safety training	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety awareness
Safety training	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety reporting
Safety training	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety promotion
Safety training	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Enforcement on safety rules
Safety training	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reward and punishment
Safety awareness	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety reporting
Safety awareness	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety promotion
Safety awareness	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Enforcement on safety rules
Safety awareness	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reward and punishment
Safety reporting	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety promotion

Safety reporting	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Enforcement on safety rules
Safety reporting	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reward and punishment
Safety promotion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Enforcement on safety rules
Safety promotion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reward and punishment
Enforcement on safety rules	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reward and punishment

Appendix S: Email invitation to Validator of AHP

2/5/23, 4:48 PM Universiti Malaysia Pahang Mail - APPOINTMENT AS AN ASSESSOR PANEL TO VALIDATE THE INSTRUMENT CONTENT ...

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my>

APPOINTMENT AS AN ASSESSOR PANEL TO VALIDATE THE INSTRUMENT CONTENT USING ANALYTICAL HIERARCHY PROCESS

5 messages

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my> Sat, Dec 11, 2021 at 3:08 PM
To: "RAFIKUL .ISLAM" <rislam@iium.edu.my>

Assalamualaikum wbt Prof,

Regarding our previous communication through whatsapp on 16 Nov 2021, I have attached the appointment letter for your kind perusal.

Name : Siti Noraishah Binti Ismail
Student ID Number : PTS20005
Field of Research : Occupational Health and Safety
Supervisors : Ts. Dr. Azizan Bin Ramli
Research Title : Safety Culture Framework for Mining Industry in Malaysia

As such, I would like to request your expertise to validate the content of the item constructs for the research so that the instrument will be significant and relevant.

Your co-operation is highly appreciated. Thank you.

Best regards,

SITI NORAISHAH ISMAIL
PhD Student
Faculty of Industrial Sciences and Technology
Universiti Malaysia Pahang

Appendix T: Appointment letters for Validator of AHP

Universiti Malaysia PAHANG

Fakulti Sains & Teknologi Industri
Faculty of Industrial Sciences & Technology

Universiti Malaysia Pahang
Lebuhraya Tun Razak
26300 Gambang, Kuantan
Pahang Darul Makmur
Tel : +609 549 2765
Faks : +609 549 2766

Our Reference : UMP.17.04/13.11/1/7 ( )
Date : December 10, 2021

PROFESOR DR. RAFIKUL ISLAM
Head of Graduate School of Management
Kulliyyah Of Economics and Management Sciences
International Islamic University Malaysia
IIUM Gombak Campus
P.O. Box 10, 50728 Kuala Lumpur

Prof.,

APPOINTMENT AS AN ASSESSOR PANEL TO VALIDATE THE INSTRUMENT CONTENT USING ANALYTICAL HIERARCHY PROCESS

We refer to the above matter.

2. Please be informed that the following student is pursuing a Doctoral Degree (PhD) at the Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang:

Name	**:**	**Siti Noraishah Binti Ismail**
Student ID Number	**:**	**PTS20005**
Field of Research	**:**	**Occupational Health and Safety**
Supervisors	**:**	**Ts. Dr. Azizan Bin Ramli**
Research Title	**:**	***Safety Culture Framework for Mining Industry in Malaysia***

3. As such, we would like to request your expertise to validate the content of the item constructs for the research so that the instrument will be significant and relevant. Attached is the related documents for your further actions (Refer Attachment 1). For any enquiries, please contact the student at 017-7598834 or email to snoraishah@ump.edu.my.

Your co-operation is highly appreciated. Thank you.

"BERKHIDMAT UNTUK NEGARA"
"*Memasyarakatkan Teknologi*"

Saya yang menjalankan amanah,

TS. DR. SAIFFUL KAMALUDDIN BIN MUZAKIR @ LOKMAN
Dean
Faculty of Industrial Sciences and Technology
☎ :+609-5492767 Faks :+609-5492766

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Appendix U: Feedback from Validator of AHP

2/5/23, 4:48 PM Universiti Malaysia Pahang Mail - APPOINTMENT AS AN ASSESSOR PANEL TO VALIDATE THE INSTRUMENT CONTENT ...

RAFIKUL .ISLAM <rislam@iium.edu.my> Sun, Dec 12, 2021 at 10:00 AM
To: "SITI NORAISHAH BINTI ISMAIL ." <snoraishah@ump.edu.my>

Dear Sr. Siti,
Assalamu alaikum. I have checked your questionnaires. You have good questionnaires, correctly formatted. I have only minor comments, you can see using Tracks (only the first sheet). Should you require any other help, please do not hesitate to contact me. Best wishes in your research.

RI

[Quoted text hidden]
[Quoted text hidden]
[Quoted text hidden]

Attachment 1_AHP Questionnaire.xlsx
39K

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my> Sun, Dec 12, 2021 at 11:31 AM
To: "RAFIKUL .ISLAM" <rislam@iium.edu.my>

Thank you for your feedback Prof
[Quoted text hidden]

Appendix V: Email invitation To Expert for Focus Group Discussion (FGD)

2/5/23, 4:47 PM Universiti Malaysia Pahang Mail - JEMPUTAN SEBAGAI PANEL PENILAI KAJIAN PHD DI DALAM SESI FOCUS GROUP DIS...

UNIVERSITI MALAYSIA PAHANG

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my>

JEMPUTAN SEBAGAI PANEL PENILAI KAJIAN PHD DI DALAM SESI FOCUS GROUP DISCUSSION (FGD)

4 messages

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my> Thu, Dec 2, 2021 at 4:17 PM
To: jatt@jresources.com

Assalamualaikum Wbt Tuan Shahrizad,

NAMA PELAJAR : SITI NORAISHAH BINTI ISMAIL
ID PELAJAR : PTS20005
BIDANG KAJIAN : OCCUPATIONAL SAFETY AND HEALTH (OSH)
TAJUK KAJIAN : SAFETY CULTURE FRAMEWORK FOR MINING INDUSTRY IN MALAYSIA
PENYELIA UTAMA : TS. DR. AZIZAN RAMLI

Dengan hormatnya perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa saya sedang mengikuti pengajian Ijazah Doktor Falsafah (Ph.D) dalam bidang berkaitan di Fakulti Sains dan Teknologi Industri, Universiti Malaysia Pahang.

3. Secara umumnya, objektif kajian saya adalah untuk mengkaji amalan dan budaya keselamatan *(safety culture)* di dalam bidang perlombongan di Malaysia serta faktor-faktor yang mempengaruhinya. Justeru itu, bagi tujuan kajian ini, saya ingin menjemput Tuan sebagai panel penilai kajian PhD di dalam sesi *Focus Group Discussion (FGD)* yang akan berlangsung seperti ketetapan berikut;

Tarikh : 13 Januari 2022
Masa : 10-11am
Medium : Atas talian platform Google Meet (pautan akan diberi kemudian)
Panel : 6 - 8 orang panel dijalankan serentak di atas talian

3. Jika Tuan bersetuju dengan jemputan ini, diharap dapat membalas emel ini berserta CV terkini Tuan untuk tindakan penyediaan surat jemputan rasmi oleh pihak fakulti. Kerjasama daripada pihak Tuan amatlah dihargai dan diucapkan jutaan terima kasih.

Sekian, terima kasih

SITI NORAISHAH ISMAIL
Pelajar PhD
Fakulti Sains dan Teknologi Industri,
Universiti Malaysia Pahang
Lebuhraya Tun Razak,26300 Kuantan,
Pahang, Malaysia.
Tel:095492832
HP No. 0177598834
Website : http://fkksa.ump.edu.my/index.php/en/

Appendix W: Appointment letters for FGD Experts (Example)

Universiti Malaysia PAHANG

Fakulti Sains & Teknologi Industri
Faculty of Industrial Sciences & Technology

Universiti Malaysia Pahang
Lebuhraya Tun Razak
26300 Gambang, Kuantan
Pahang Darul Makmur
Tel. : +609 549 2765
Faks : +609 549 2766

Rujukan Kami : UMP.17.04/13.11/1/7 ( )
Tarikh : 27 Disember 2021

ENCIK JOHN ANAK MITTIS
Coal Mining Consultant / Coal Exploration Executive
Piritemp Sdn. Bhd.
Suite 1.1, First Floor
Lot 2643, Green Road
934000 Kuching, Sarawak

Tuan,

JEMPUTAN SEBAGAI PANEL PENILAI DAN PENGESAH HASIL DAPATAN KAJIAN PHD DI DALAM SESI *FOCUS GROUP DISCUSSION (FGD)*

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa pelajar berikut sedang mengikuti program Ijazah Doktor Falsafah (Ph.D) di Fakulti Sains dan Teknologi Industri (FSTI), Universiti Malaysia Pahang:

Nama Pelajar	:	**Siti Noraishah Binti Ismail**
ID Pelajar	:	**PTS20005**
Bidang Kajian	:	**Occupational Health and Safety (OHS)**
Tajuk Kajian	:	**Safety Culture Framework for Mining Industry in Malaysia**
Penyelia Utama	:	**Ts. Dr. Azizan Ramli**

3. Objektif kajian pelajar adalah untuk mengkaji amalan dan budaya keselamatan (*safety culture*) di dalam bidang perlombongan di Malaysia serta faktor-faktor yang mempengaruhinya. Justeru itu, bagi tujuan kajian beliau, pihak pengurusan fakulti ingin menjemput tuan sebagai panel penilai dan pengesah hasil kajian PhD di dalam sesi *Focus Group Discussion (FGD)* pelajar tersebut yang akan berlangsung seperti ketetapan berikut;

Tarikh	:	**13 Januari 2022 (Khamis)**
Masa	:	**10:00 pagi hingga 11:00 pagi**
Medium	:	**Platform *Google Meet* (pautan akan diberi kemudian)**

4. Sekiranya pihak tuan memerlukan maklumat lebih lanjut, sila hubungi pelajar, Saudari Siti Noraishah binti Ismail di talian 017-7598834 atau di alamat e-mel snoraishah@ump.edu.my. Kerjasama daripada pihak tuan amatlah dihargai dan diucapkan jutaan terima kasih.

"BERKHIDMAT UNTUK NEGARA"
"***Memasyarakatkan Teknologi***"

Saya yang menjalankan amanah,

TS. DR. SAIFFUL KAMALUDDIN BIN MUZAKIR @ LOKMAN
Dekan
Fakulti Sains dan Teknologi Industri
☎ :+609-5492767 Faks :+609-5492766

AA/Surat/Pengajian Siswazah/Rekod Pelajar

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Appendix X: Email on requesting permission to a volunteered mining company to conduct a case study

2/5/23, 5:03 PM Universiti Malaysia Pahang Mail - PERMOHONAN MENJALANKAN KAJIAN LAPANGAN

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my>

PERMOHONAN MENJALANKAN KAJIAN LAPANGAN

1 message

SITI NORAISHAH BINTI ISMAIL . <snoraishah@ump.edu.my> Thu, Mar 3, 2022 at 11:10 PM
To: Amran Wahid <mamran50@gmail.com>

Assalamualaikum wbt YBhg. Dato',

MEMOHON KEBENARAN MENJALANKAN KAJIAN LAPANGAN DI LEMBING RESOURCES SDN BHD

NAMA PELAJAR	: SITI NORAISHAH BINTI ISMAIL
ID PELAJAR	: PTS20005
BIDANG KAJIAN	: OCCUPATIONAL SAFETY AND HEALTH (OSH)
TAJUK KAJIAN	: SAFETY CULTURE FRAMEWORK FOR MINING INDUSTRY IN MALAYSIA
PENYELIA UTAMA	: TS. DR. AZIZAN RAMLI

Dengan hormatnya perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa saya sedang mengikuti program Ijazah Doktor Falsafah (Ph.D) dalam bidang berkaitan di Fakulti Sains dan Teknologi Industri, Universiti Malaysia Pahang.

3. Objektif kajian adalah untuk mengkaji amalan dan budaya keselamatan (*safety culture*) di dalam bidang perlombongan di Malaysia serta faktor-faktor yang mempengaruhinya. Justeru itu, bagi tujuan kajian ini, saya ingin memohon kebenaran Dato' untuk menjalankan kajian lapangan yang akan berlangsung seperti ketetapan berikut;

Tarikh Tentatif	: 4 Julai – 4 Oktober 2022
Masa	: 8.30 pagi -430 petang
Tempoh	: 3 bulan
Mod kajian lapangan	: Pemerhatian/ sesi temubual dan soal selidik

3. Dilampirkan surat Borang Jawapan Persetujuan seperti di **Lampiran A**. Mohon kembalikan **Lampiran A** tersebut sekiranya pihak Dato' bersetuju untuk dengan permohonan ini. Kerjasama daripada pihak Dato' amatlah dihargai dan diucapkan jutaan terima kasih.

Sekian, terima kasih

SITI NORAISHAH ISMAIL
Lecturer/ PhD Student
Faculty of Chemical and Process Engineering Technology
Universiti Malaysia Pahang
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SURAT PERMOHONAN KAJIAN LAPANGAN_ SITI NORAISHAH FSTI.pdf
99K

Universiti Malaysia Pahang
Fakulti Sains & Teknologi Industri
Faculty of Industrial Sciences & Technology

Rujukan Kami : UMP.17.04/13.11/1/7 (   )
Tarikh : 3 Mac 2022

DATO' HAJI MOHD AMRAN BIN HAJI WAHID
Pengarah Urusan
Lembing Resources Sdn. Bhd.
(Myah Mines Sdn Bhd)
A-19, 2nd Floor, Lorong Galing 2 Off Jalan Beserah
25300 Kuantan Pahang

YBhg. Dato',

MEMOHON KEBENARAN MENJALANKAN KAJIAN LAPANGAN DI LEMBING RESOURCES SDN. BHD.

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa pelajar berikut sedang mengikuti program Ijazah Doktor Falsafah (Ph.D) di Fakulti Sains dan Teknologi Industri (FSTI), Universiti Malaysia Pahang:

Nama Pelajar	:	**Siti Noraishah Binti Ismail**
ID Pelajar	:	**PTS20005**
Bidang Kajian	:	**Occupational Health and Safety (OHS)**
Tajuk Kajian	:	**Safety Culture Framework for Mining Industry in Malaysia**
Penyelia Utama	:	**Ts. Dr. Azizan Ramli**

3. Objektif kajian pelajar adalah untuk mengkaji amalan dan budaya keselamatan *(safety culture)* di dalam bidang perlombongan di Malaysia serta faktor-faktor yang mempengaruhinya. Justeru itu, bagi tujuan kajian beliau, pihak pengurusan fakulti ingin memohon kebenaran YBhg. Dato' untuk menempatkan pelajar berikut bagi menjalankan kajian lapangan yang akan berlangsung seperti ketetapan berikut:

Tarikh Tentatif	**: 4 Julai 2022 – 4 Oktober 2022**
Masa	**: 8:30 pagi – 4:30 petang**
Tempoh	**: tiga (3) bulan**
Mod kajian lapangan	**: Pemerhatian / sesi temubual dan soal selidik**

4. Dilampirkan surat Borang Jawapan Setuju Terima seperti di **Lampiran A**. Mohon kembalikan kepada pelajar sekiranya pihak YBhg. Dato' bersetuju untuk dengan permohonan menjalankan kajian lapangan ini.

5. Sekiranya pihak YBhg. Dato' memerlukan maklumat lebih lanjut, sila hubungi pelajar, Saudari Siti Noraishah binti Ismail di talian 017-7598834 atau di alamat e-mel snoraishah@ump.edu.my. Kerjasama daripada pihak YBhg. Dato' amatlah dihargai dan diucapkan jutaan terima kasih.

"WAWASAN KEMAKMURAN BERSAMA 2030"

"BERKHIDMAT UNTUK NEGARA"
"Memasyarakatkan Teknologi"

Saya yang menjalankan amanah,

TS. DR. SAIFFUL KAMALUDDIN BIN MUZAKIR @ LOKMAN
Dekan
Fakulti Sains dan Teknologi Industri
☎ :+609-4315705

AA/Surat/Pengajian Siswazah/Rekod Pelajar

Appendix Y: Approval letter to conduct case study at volunteered mining company

LAMPIRAN A: SURAT MAKLUMBALAS PERSETUJUAN PENEMPATAN PELAJAR PhD MENJALANKAN KAJIAN LAPANGAN DI MYAH MINES SDN. BHD.

Tarikh: 22 / 3 / 2022

Kepada;

TS. DR. AZIZAN RAMLI
Penyelia Utama

Salinan kepada;

TS. DR. SAIFFUL KAMALUDDIN BIN MUZAKIR @ LOKMAN
Dekan
Fakulti Sains dan Teknologi Industri

Yg Berusaha Dekan,

SURAT MAKLUMBALAS SETUJU TERIMA BAGI PENEMPATAN PELAJAR PhD MENJALANKAN KAJIAN LAPANGAN DI MYAH MINES SDN. BHD.

Dengan hormatnya saya merujuk surat tuan dalam siri Rujukan: UMP.17.04/13.11/1/7 yang bertarikh 3 Mac 2022, saya bagi pihak **SYARIKAT** dengan ini ***BERSETUJU/ ~~TIDAK~~ BERSETUJU** menerima pelajar daripada fakulti tuan untuk menjalankan kajian lapangan di **SYARIKAT** kami.

Bersama ini dikembalikan Borang Jawapan Setuju Terima untuk makluman pihak tuan selanjutnya.

Sekian, terima kasih.

Yang benar,

Nama: Mr Chai Tham Poh.
Jawatan: Managing Director.
Nama Syarikat: Lembing Resources Sdn Bhd.
Cop Syarikat:
LEMBING RESOURCES SDN. BHD. (791893-P)
No A-19, 1st Floor,
Lorong Galing 2, Off Jalan Beserah,
25300 Kuantan, Pahang.
Tel: 09-517 2107
Fax: 09-517 2106

LIST OF PUBLICATIONS (Published in Year 2021 until Dec 2023)

No.	List of publications in Q1 and other journals	UMPIR
1.	Noraishah, S., & Ramli, A. (2023). Investigate the factors affecting safety culture in the Malaysian mining industry. Resources Policy, 85(PA), 103930. https://doi.org/10.1016/j.resourpol.2023.103930 (Q1, Impact Factor = 8.222)	http://umpir.ump.edu.my/id/eprint/38466/
2.	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(Q1, Impact Factor = 8.222)	http://umpir.ump.edu.my/id/eprint/31874/
3.	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 (Q1, Impact Factor = 6.1)	http://umpir.ump.edu.my/id/eprint/31866/
4.	Ismail, S.N., Ramli, A., Abdul Aziz, H., Morshidi, A., Zainal Abidin, M.F. (2023). Establishing an Organisational Safety Culture System In The Malaysian Mining Industry. 10(2), 73–88. Journal of Business and Social Development Volume 10 Number 2, September 2022: 73-88 DOI: http://doi.org/10.46754/jbsd.2022.09.005	http://umpir.ump.edu.my/id/eprint/38464/
5.	Ismail S.N., Ramli A. (2022) Does Human Factor Contribute to Mining Accidents? A Systematic Literature Review Approach. Human-Centered Technology for a Better Tomorrow. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-16-4115-2_48	http://umpir.ump.edu.my/id/eprint/38460/
6.	Ismail, S. N., Ramli, A., Abdul Aziz, H. (2022). Does expert judgement is important in mining industry?: A systematic literature review study. Journal of Governance and Integrity, 5(2), 249–266. https://doi.org/10.15282/jgi.5.2.2022.7135	http://umpir.ump.edu.my/id/eprint/35099/
7	Ameer, S. M., Noraishah, I. S., Azizan, R., & Ratih, D. (2022). Investigation of the Factors Contributing to Unsafe Behaviour of Iron Ore Miners in Malaysia. Current Science And Technology (CST) Vol. 02, Issue 1, 30 – 39 DOI: https://doi.org/10.15282/cst.v2i1.7609	http://umpir.ump.edu.my/id/eprint/37095/