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Original Article

Application of Delphi technique and analytic hierarchy process to prioritize the occupational health and safety management system requirements

Kosolsaksakul P[1], Ketsakorn A[1]

[1] Faculty of Public Health, Thammasat University (Rangsit Center), Klong Luang, Pathumthani, Thailand

Corresponding author:
Arroon Ketsakorn,
Associate Professor, Occupational Health and Safety,
Faculty of Public Health,
Thammasat University (Rangsit Center), Thailand
E-mail: arroon.k@fph.tu.ac.th
Tel.: +66954914564
ORCID ID: https://orcid.org/0000-0002-4418-2278

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ABSTRACT

Introduction: Occupational health and safety (OH&S) in small organizations are still unable to meet OHS requirements. This may have an impact on the health and safety of employees. There are many requirements for ISO 45001implementation. Many organizations lack sufficient evidence regarding which requirements are important and must be prioritized for system implementation. This study aimed to determine the importance of weights (IW) from OHS requirements including setting new optional requirements for use as OHS guidelines.

Methods: The study was conducted from August and September 2023. Data collection involved using standardized questionnaires related to ISO 45001 requirements and additional requirements based on expert's opinions. Delphi technique and Analytic Hierarchy Process (AHP) were used for data analysis.

Results: The IW from ISO45001 requirements included the context of the organization (IW=0.203), leadership and worker participation (IW=0.254), planning (IW=0.184), support (IW=0.100), operation (IW=0.102), performance evaluation (IW=0.076) and improvement (IW=0.081). The leadership and worker participation were the highest of IW, while the performance evaluation indicated the lowest of IW. In addition, the new optional requirement apart from ISO 45001 indicated that there were nine essential requirements of significance. These requirements included business competition in the market, product safety development, product pricing cost, modern machinery and equipment used for production processes, work experience, budget allocation for safety control and system supervisor, operations, compliance with laws and regulations, safety recommendations and hazard control.

Conclusion: Prioritization of ISO 45001 requirements could use the implementation guidelines effectively. In addition, the inclusion of relevant new requirements also increased confidence in protecting the safety of employees.

Keywords: Analytic Hierarchy Process, Delphi technique, ISO 45001, Occupational Health and Safety

Introduction

The International Organization for Standardization (ISO) is an organization that issues various standards related to business and industry, such as ISO 9001 for Quality Management Systems (QMS), ISO 14001 for Environmental Management Systems (EMS), and ISO45001 for Occupational Health and Safety Management Systems (OHSMS). These standards are globally recognized as effective methods for assessing and auditing management systems.

ISO45001 helps to control risks for employees, visitors, or external contractors, and assists organizations in establishing processes for continual improvement in Occupational Health and Safety (OH&S).[1] Achieving an OHSMS demonstrates an organization's commitment to the well-being of its employees and third parties. A good OHSMS can benefit both the organization and its employees by reducing costs and workplace accidents.[2] This standard is suitable for all types of organizations looking to improve efficiency in management and reduce workplace accidents. An effective OHSMS also benefits an organization's partners and provides a competitive advantage.[3-4]

Previous studies related to establishing requirements and guidelines in OH&S through experts' judgement[5], such as Parimonthonsakul[6], focused on the selection of information technology management standards using the Analytic Hierarchy Process (AHP); this study used in-depth interviews to select a standard system. Phattharasetsophon[7] studied the factors affecting customer satisfaction in marketing by using AHP method for computing the important weights. There are additional studies, such as Phangchandha and Ketsakorn[8], who conducted a study on the new risk assessment criteria in the fuel oil transfer process. This study was to establish the new opportunity criteria and calculate the relative weight of likelihood criteria using the Delphi technique and AHP. Senchanthichai[9] studied future trends in cosmetics products for the next 5 years using the Delphi technique. Bunmee, Chaemchanya and Asavakovitphong[10] studied on the temporary shelter location selection during air pollution disasters caused by $PM_{2.5}$ using the Delphi technique and Pimoonchat[11] studied the development of safety risk assessment criteria in the process of traction battery charging for electrical forklift. There is also a study by Panjawongroj[12] focused on the problem of prioritizing criteria and selecting sustainable management systems. Many studies have been undertaken to identify suitable criteria for different types of industries or organizations and criteria beyond standard requirements for consideration. However, when considering the complexity of standard requirements and the weighting of their importance, it remains ambiguous and varies.

According to ISO 45001, there are 7 keys requirement: organizational context (Clause 4), leadership and participation (Clause 5), planning (Clause 6), support (Clause 7), operation (Clause 8), performance evaluation (Clause 9), and improvement (Clause 10). All the literature reviews focused on the prioritization of requirements in OHSMS but there is no focus on a new tool for calculating the important weights of OHSMS requirements. There is still a lack of reliable OHSMS requirements assessment for reduction of bias in individual experts' judgement. Therefore, this study aimed to determine the important weights of OHSMS requirements and other requirements affecting OHSMS that should be considered in combination with existing requirements.

Methods

A cross-sectional study was conducted from August and September 2023 in electrical and electronic home appliances, Samut Sakhon province, Thailand. This industry was selected by considering the prioritization of OH&S problems, namely, attention to problems of staff, attention of management to problem solving, problem size, including not being certified with ISO 45001. An instrument for data collection consisted of the OHSMS requirements and other requirements affecting the occupational health and safety management system. Expert Choice version 11 was used in computing the important weights from an AHP structure and determining the prioritization of OHSMS requirements. The Delphi technique was used to identify the other factors that may affect existing OHSMS requirements.[13,14] Assessment forms and ISO 45001 requirements were included in this study. There were 17 experts: 8 university professors and 9 OH&S professionals in the organization. All experts were selected for a purposive sampling

method and more than 5 years' experience in occupational health and safety. The statement indicates that the rate of error reduction in each process or system was minimal and reached a stable level of 0.02 when the number of experts involved was 17 or more.[5] To evaluate the ISO 45001 requirements and other factors that may affect existing OHSMS requirements. The questionnaires were developed by researchers which were approved by 3 experts before data collection with IOC; 0.70-1.00.[15, 16]

Delphi technique was used for discovering other factors that may affect existing OHSMS requirements.[17,18] This technique was classified into three rounds:

In the first round: an open-ended questionnaire was created. All experts were asked to provide their opinions freely, and the questionnaire included rating scale to measure the importance of various factors.[19]

The second round used a closed-end questionnaire with a rating scale (1 to 5), where 5 indicated the highest agreement and 1 indicated the lowest agreement. The questionnaire contained similar questions to the first round but with the addition of statistical values. Median and Interquartile Range (IQR) values were considered in this round. The numerical values of median consideration and IQR values were evaluated. These numerical values ranged from 1-5. The highest-level criterion, high-level criterion, medium-level criterion, low-level criterion, and the lowest-level criterion displayed the median numerical values of 4.50 to 5.00, 4.00 to 4.49, 3.50 to 3.99, 2.50 to 3.49, and less than 2.49, respectively.[20]

Expert Choice software version 11 was used for computing important weights from an AHP structure.[21,22] The Expert Choice is software for cooperative decision-making solutions that are based on multicriteria decision making. This software helps organizations make better decisions and manage risk with speed, transparency, and alignment. Expert Choice implemented the AHP of Saaty[19] and has been used in fields such as manufacturing and environmental management[23], shipbuilding[24] and agriculture.[11] This tool was used to compute the important weights by brainstorming of expert's judgement. The AHP provided a structural framework is shown in Figure 1. The scale of 1–9 was quantified for pairwise comparison on each level of the hierarchy. The most used is the linear scale in Table 1 that was proposed by Saaty[19], probably because it was integrated into the leading Expert choice software program.

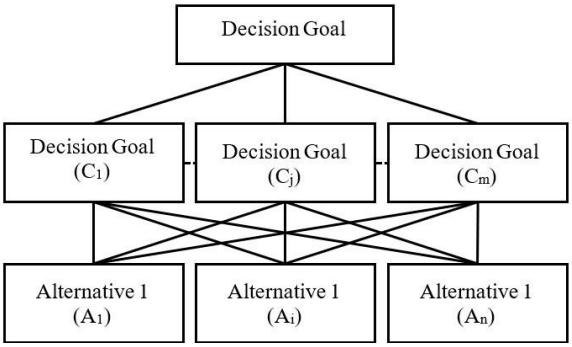

Figure 1: A three-level decision hierarchy.

Table 1: Numerical value pairwise comparison scale of Saaty.[19]

Numerical rating	Description
1	Equivalently
2	Equivalently to neutrally more
3	Neutrally more
4	Neutrally to greatly more
5	Greatly more
6	Greatly to very greatly more
7	Very greatly more
8	Very greatly to extremely more
9	Extremely more

The pairwise comparisons between the decision and alternative criteria were conducted by asking OH&S expert's questions. The answers to those questions were given in an $m \times m$ pairwise comparison matrix, stated as follows in Equation (1).

$$A = (a_{ij})_{m\times m} = \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_m \end{matrix} \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1m} \\ a_{21} & a_{22} & \cdots & a_{2m} \\ \vdots & \vdots & \cdots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \quad (1)$$

Where a_{ij} denoted a numerical judgment on w_i/w_j with $a_{ii} = 1$ and $a_{ij} = 1/a_{ji}$ for $i, j = 1, \ldots, m$. On condition that the pairwise comparison matrix $A = (a_{ij})_{m\times m}$ fulfilled $a_{ij} = a_{ik}a_{kj}$ for any $i, j, k = 1, \ldots, m$,

afterwards, A was said to be magnificently consistent; otherwise, it was said to be inconsistent. The pairwise comparison matrix A and the weight vector W was computed by solving Equation (2).

$$AW = \lambda_{max} W \quad (2)$$

Where λ_{max} was the maximum eigenvalue of A. The answers from experts may not be competent enough to contribute to ideally accordant pairwise comparisons, Therefore, it was determined that the pairwise comparison matrix A had acceptable regularity, which was examined by the following consistency ratio (C.R.), as expressed in Equation (3).

$$C.R. = \frac{(\lambda_{max} - n)/(n-1)}{RI} \quad (3)$$

Where Random consistency Index (RI) was a random inconsistency index; those values deviated with the order of the pairwise comparison matrix. The RI values for the pairwise comparison matrices with the order from 1 to 10; order (n) 1,2,…,10 described the RI values of 0,0, 0.58, 0.90, 1.12, 1.24, 1.32, 1.41, 1.45, and 1.49, respectively.[19] C.R. $\leqslant$ 0.1 pairwise comparison matrix was considered acceptable consistency. On the other hand, it must be corrected.

Alternatives were considered pairwise regarding each decision criterion. After the weights of decision criteria and the weights of decision alternatives were achieved by using pairwise comparison matrices, the overall weight of each decision alternative regarding the decision goal was produced by the following addition weighting method[19], as expressed in Equation (4).

$$w_{Ai} = \sum_{j=1}^{m} w_{ij}\, w_j, i = 1, \ldots, n \quad (4)$$

Where w_j (j = 1, ..., m) were the weights of decision criteria, w_{ij} (i = 1, … ,n) were the weights of decision alternatives regarding criterion j, and w_{Ai} (i = 1, … , n) were the overall weights of decision alternatives. The best decision alternative was the one that had the greatest overall weight relative to the decision goal.

Expert Choice implemented the AHP that was used for computing the relative weight, instead of calculating by hand according to Equations (1)-(4). The determination of each weighting criteria and weighting attribute were assumed using a pairwise comparison matrix provided by decision-makers based on the Delphi MAH technique developed by the Rand Corporation Company and the maximize agreement heuristic (MAH).[25] This technique consisted of three steps: the numerical data were acquired from the OHS experts[26], all decision data were averaged, and average values from all the decision-makers were considered.

Results

The assessment of relative weight was based on brainstorming with OH&S experts. Expert Choice V.11 implemented the AHP[27] for computing the important weights of each OHSMS requirement. The result is shown in Figure 2. The OHSMS requirements were categorized into seven elements. A pairwise comparison matrix for the seven alternative criteria was provided by decision-makers. Table 2 shows the relative weight based on the Delphi MAH technique.[28, 29]

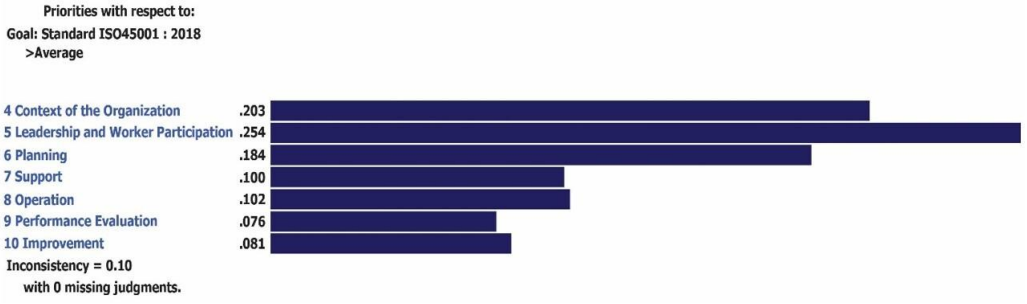

Figure 2: Importance weight of ISO 45001 using Expert Choice V.11 program.

Table 2: Relative weight based on the Delphi MAH technique.

ISO 45001 requirements	No. 1	No. 2	No. 3	No. 4	No. 5	…	No. 17	Average weight
4 and 5	1	1/9	9	3	1/5	…	1/4	2.27
4 and 6	4	1/7	3	1/4	1/3	…	1/6	0.86
4 and 7	1/3	1/9	1	1	1/3	…	1/4	1.96
4 and 8	1/3	1/7	1	1/3	1/7	…	1/4	1.58
4 and 9	1	1/5	2	1/2	1/5	…	1/9	2.47
4 and 10	1	1/5	1	1/2	1/5	…	1/9	1.94
5 and 6	4	3	9	1	3	…	1	3.21
5 and 7	1	3	3	3	3	…	1/4	2.48
5 and 8	5	5	2	1	3	…	1/6	3.84
5 and 9	5	3	1	2	1	…	1/9	2.65
5 and 10	4	3	1	1	3	…	1/9	2.53
6 and 7	1/3	3	1/2	1	3	…	1	3.17
6 and 8	1	1/3	1	1/3	3	…	1/9	1.07
6 and 9	1	3	1	1/2	3	…	1/9	2.52
6 and 10	1	1/3	1	1	1/3	…	1/9	2.20
7 and 8	4	3	6	1/3	1/3	…	1/4	2.28
7 and 9	5	1/3	1	1/2	1/3	…	1/9	1.71
7 and 10	4	1/3	1	1/3	1/3	…	1/9	0.55
8 and 9	1	3	1	1	5	…	1/4	2.23
8 and 10	1	3	1	1	3	…	1/9	1.43
9 and 10	1	3	1	1	3	…	1/9	2.01

The pairwise comparison of the requirements showed that leadership and worker participation were the most important of the alternative criteria (25.4%). Performance evaluation requirement showed the lowest important weight (7.6%).

The calculation of the consistency ratio was divided into the following steps.

(1) Relative weight of the consistency and the maximum eigenvalue (λ_{max}) for each matrix from Table 3 based on the number of alternative criteria (n).

(2) Consistency index calculation for each matrix based on the number of alternative criteria (n) $CI=(\lambda_{max}-n)/(n-1)$ = (7.804-7)/ (7-1) = 0.134

(3) Consistency ratio calculation, which was $C.R. = CI/RI$ = 0.134/ 1.32=0.10

Table 3: Maximum eigenvalue (λ_{max}).

ISO 45001 requirement C.R.⩽0.1	A	B	C	D	E	F	G	Horizontal sum of value
A	1.00	2.27	0.86	1.96	1.58	2.47	1.94	0.208
B	0.44	1.00	3.21	2.48	3.84	2.65	2.53	0.247
C	1.16	0.31	1.00	3.17	1.07	2.52	2.20	0.172
D	0.51	0.40	0.32	1.00	2.28	1.71	0.55	0.101
E	0.63	0.26	0.94	0.44	1.00	2.23	1.43	0.106
F	0.41	0.38	0.40	0.59	0.45	1.00	2.01	0.080
G	0.52	0.40	0.46	1.82	0.70	0.50	1.00	0.086
Vertical sum of value	4.67	5.02	7.17	11.45	10.92	13.08	11.66	1.000
Eigenvalue: λ_{max}	0.971	1.240	1.237	1.159	1.155	1.042	0.999	7.804

Notes: A is organization; B is leadership; C is planning; D is support; E is operation; F is performance; G is improvement

In addition, this study found the new requirements apart from ISO 45001 that may affect the occupational health and safety system. There were nine essential requirements. These requirements included business competition in the market, product safety development, product pricing cost, modern machinery and equipment used for production processes, work experience, budget allocation for safety control and system supervisor, operations, compliance with laws and regulations, safety recommendations, and hazard control as shown in Table 4. The median and interquartile ranges of all additional essential requirements indicated that those criteria should be given additional importance.

Table 4: Additional essential requirements using Delphi technique.

No	Requirements	Literature	Expert	IOC	Round 2		Round 3	
					Median	IQR	Median	IQR
1	Business competition in the market	●	●	1.00	4.29	1.00	4.47	1.00
2	Product safety development	●	●	0.67	4.29	1.00	4.41	1.00
3	Product pricing cost	●	●	1.00	4.06	1.00	4.18	1.00
4	Modern machinery and equipment used for production processes	●	●	1.00	4.18	1.00	4.35	1.00
5	Work experience	●	●	1.00	4.12	1.50	4.12	1.50
6	Budget allocation for safety control and system supervisor	●	●	1.00	4.53	1.00	4.53	1.00
7	Operation compliance with laws and regulations	●	●	1.00	4.59	1.00	4.65	1.00
8	Safety recommendations	●	●	1.00	4.35	1.00	4.47	1.00
9	Hazard control	●	●	1.00	4.71	1.00	4.71	1.00

Note: IQR is interquartile range

All additional essential requirements were also assessed, the relative weight using Expert Choice V.11 based on brainstorming from OHS experts. The result is shown in Figure 3.

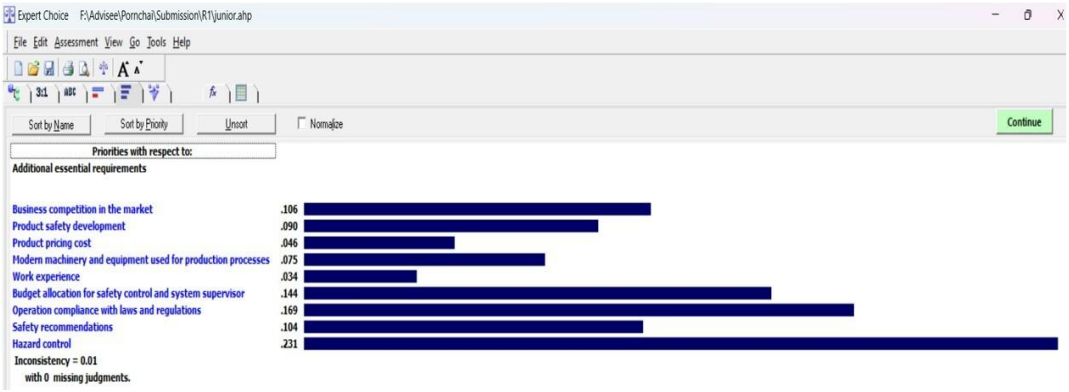

Figure 3: Importance weight of additional essential requirements using Expert Choice V.11 program.

Discussion

OHSMS requirements prioritization is important in occupational health and safety.[30] The relative weight assessment must be reliable for OHSMS requirements prioritization. Consequently, this study focused on conducting as AHP using Expert Choice V.11 program to determine the important weights of each requirement to estimate prioritize the OHSMS requirements in the electrical appliance manufacturing industry in Samutsakhon province, Thailand. Consistency Ratio (C.R.) was shown as 0.10. This Consistency Ratio (C.R.) indicated an acceptable level of consistency in the pairwise comparison.[31] ISO 45001 requirements were assessed as the important weights of each requirement. Leadership and worker participation requirement showed the highest important weights of 0.254. Because the key to creating a successful system requires everyone's participation and organizational leaders must set serious operational policies. This finding was consistent with the study of Suebsap, Khacharanan and Tangsuwan[32] and Aksornpim.[1] These previous studies stated that all employees increased involvement in understanding the risk within their work contributed to improvement the efficiency of managing safety and occupational health. On the other hand, the performance evaluation requirement indicated the lowest important weight of 0.076. The performance evaluation was the result after the work has been carried out, which was consistent with the study of Rueanngen[33], Ruechakul, Kulchatchai, and Satyaprasert[34], and Otitolaiye et al.[35] These previous studies stated that the ISO 45001 was final process of requirement were performance evaluation such as monitoring, auditing and management review. There were additionally nine essential requirements using Delphi technique. These requirements involved business competition in the market, product safety development, product pricing cost, modern machinery and equipment used for production processes, work experience, budget allocation for safety control and system supervisor, operations, compliance with laws and regulations, safety recommendations and hazard control. These requirements should be further considered to strengthen the organization's ability to implement an occupational health and safety management system. These findings were consistent with the study of Patasetasopol[7] and Senchanthichai[9] stated that the future of product manufacturing and development involved modern production processes utilizing machinery that assists manufacturers in working more accurately, precisely, and swiftly. These considerations for the safety of workers and the environment. Additionally, product development focuses on highly efficient innovations to enhance product quality, pricing strategies, and marketing techniques.

This study provides useful information for practitioners in the field of occupational health and safety in organizations to initiate appropriate compliance with relevant standards. The implementation of a workplace health and safety management system should start with the most important requirements. In addition, considering other factors related to the workplace health and safety system may also increase the effectiveness of preventing hazards in the workplace. The principles and activities for improving the Delphi technique outcomes are broadly applicable across various industries, including the electronics sector and other related fields. Here's how these principles can be tailored and applied to organizations in the electronics industry and similar sectors.

Limitations

Limitations of this study were based on the survey of only one company and brainstorming of OH&S experts for determining the relative weight assessment. Therefore, it may not represent the actuality of the situation due to time limitation and resources available. However, it represented the general facts.

Conclusion

This study would be useful information for practitioners in the field of OH&S within

organizations to initiate practices correctly in accordance with applicable standards. The implementation of occupational health and safety management system requirements should be started with the most important requirements. In addition, consideration of other relevant factors in occupational health and safety systems may also increase the efficiency of preventing occupational hazards as well. Further studies may be expanded with another technique for computing the important weights of occupational health and safety system requirements such as fuzzy analytic hierarchy process (FAHP) approach to manage uncertainty in a better way.

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References

1. Aksornpim N, Chompunth C. Factors contributing to the sucess of environmental management standard (ISO 14001:2015) and occupational health and safety mangement standard (ISO 45001:2018) of A forklift distribution company in Amata city Chonburi industrial estate. Journal of Environmental Management. 2022;18(1):18-35. Available from: https://doi.org/10.14456/jem.2022.2
2. Kookaew J. Success factors for occupational health and safety management A cse study in a Frizen food business: Thammasat University. 2011. Available from: https://digital.library.tu.ac.th/tu_dc/frontend/Info/item/dc:120641
3. American National Standards Institute: ANSI. ISO 45001:2018 Occupational health and safety management systems – requirements with guidance for use. 2018. Available from: https://blog.ansi.org/iso-45001-2018-occupational-health-safety-management-systems/
4. Naidu MB. Corporate sustainability: How can GRI guidelines and ISO standards complement each other and relate with the SDGs?. 2020. Available from: https://www.diva-portal.org/smash/record.jsf?pid=diva2:1444478
5. Macmillan TT. The Delphi Technique. 1971. Available from: https://eric.ed.gov/?id=ED064302
6. Parimontonsakul V. Infromation technology standard selection approach by Analytic Hierarchy Process (AHP) Case study: A printing company: Tammasat University. 2009. Available from: https://digital.library.tu.ac.th/tu_dc/frontend/Info/item/dc:123353
7. Patasetasopol W. Factors affecting customer satisfaction in a private company analytical instrument division: Thammasat University. 2017. Available from: https://archive.cm.mahidol.ac.th/handle/123456789/4534
8. Phangchandha R, Ketsakorn A. A new risk assessment criteria in the process of fuel oil unloading. Science and Technology RMUTT Journal. 2021;8:89-105. Available from: https://ph02.tci-thaijo.org/index.php/past/article/view/243049/164917
9. Seanjantichai R. Cosmetics product trends 5 years (2020-2024) through Delphi technique. 2020. Available from: http://www.mbaoneday-abstract.ru.ac.th/index.php/abstractData/viewIndex/157
10. Boonmee C, Chamchanya S, Atsawakowitphong P. Temporary shelter-site selection during $PM_{2.5}$ air pollution disaster via analytic hierarchy process: A case study of Chiang Mai University. Naresuan University Engineering Journal. 2020;15(2):75-89. Available from: https://ph01.tci-thaijo.org/index.php/nuej/article/view/240885
11. Phimoolchat S. Development of safety risk assessment criteria in the process of traction battery charging for electrical Forklift: Thammasat University. 2021. Available from: https://digital.library.tu.ac.th/tu_dc/frontend/Info/

item/dc:191988

12. Panjavongroj S. Hybrid approaches for prioritization Fuzzy pairwise comparison matrices in multiple attribute decision marking: Thammasat University. 2021. Available from: https://digital.library.tu.ac.th/tu_dc/frontend/Info/item/dc:299379
13. Dalkey N. An experimental study of group opinion: the Delphi method. Futures. 1969;1(5):408-26. Available from: https://doi.org/10.1016/S0016-3287(69)80025-X
14. Dalkey N, Helmer O. An experimental application of the Delphi method to the use of experts. Management Science. 1963;9(3):458-67. Available from: https://doi.org/10.1287/mnsc.9.3.458
15. Meesil N. Delphi Technique: Avoidance of misconception. Veridian E-Journal, Silpakorn University. 2016; 9(1):1256-67. Available from: https://he02.tci-thaijo.org/index.php/Veridian-E-Journal/article/view/61679/50809
16. Murry JW, Hammons JO. Delphi: A versatile methodology for conducting qualitative research. The Review of Higher Education. 1995;18(4):426-36. Available from: http://doi:10.1353/rhe.1995.0008
17. Chianchana C. Development of an educational sustainability assessment model: Application of the Delphi technique and pilot study. Journal of Education and e-Learning Research. 2022;9(2):119-28. Available from: http://doi:10.20448/jeelr.v9i2.4044
18. Colclasure B. Entry-level workplace competencies needed by graduates of a community college agriculture program: A Midwest case study using the Delphi technique. Journal of Research in Technical Careers. 2020;4(2):3-23. Available from: http://doi:10.9741/2578-2118.1083
19. Saaty TL. Decision making—the analytic hierarchy and network processes (AHP/ANP). Journal of Systems Science and Systems Engineering. 2004;13:1-35. Available from: http://doi.org/10.1007/s11518-006-0151-5
20. Giannarou L, Zervas E. Using Delphi technique to build consensus in practice. International Journal of Business Science and Applied Management. 2014;9(2):65-82. Available from: http://doi.org/10.69864/ijbsam.9-2.106
21. Kwong C-K, Bai H. A Fuzzy AHP approach to the determination of importance weights of customer requirements in quality function deployment. Journal of Intelligent Manufacturing. 2002;13(5):367-77. Available from: http://doi.org/10.1023/A:1019984626631
22. Kanchanasuwan P. Application of The Analytic Hierarchy Process (AHP) Toward Decision Making to use The Technology in Garment Factory: Thammasat University. 2017. Available from: https://digital.library.tu.ac.th/tu_dc/frontend/Info/item/dc:139687
23. Surapol T, Chompunth C. An analysis of occupational, safety and environmental management: A case study of a petrochemical and distillation industry in Rayong province. Ph.D. in Social Sciences Journal. 2018;8(3):40-52. Available from: http://doi:10.14456/phdssj.2018.59
24. Chaiyarat S. An application of Fuzzy analytical hierarchy process of dust explosion in the process of tapioca starch: Thammasat University. 2020. Available from: https://digital.library.tu.ac.th/tu_dc/frontend/Info/item/dc:182200
25. Sever D, Bostanci KT. The competencies of science teacher: A Delphi study. European Journal of Education Studies. 2020;7(6):82-112. Available from: http://doi:10.5281/zenodo.3887330
26. Sosnytskyi YO, Sikorskyi PI, Bezborodykh SM, Morozova MM, Moroz VP. Application of the Delphi technique to determine the technological competencies of a faculty member. European Journal of Educational Research. 2021;10(4):2089-103. Available from: https://doi.org/10.12973/eu-jer.10.4.2089
27. Chang D-Y. Applications of the extent analysis method on Fuzzy AHP. European Journal of Operational Research. 1996;95(3):649-55. Available from: https://doi.org/10.1016/0377-2217(95)00300-2
28. Dhatsiwat C. The Delphi technique researching. 2020. Available from: https://opacdb02.dpu.ac.th/cgi-bin/koha/opac-detail.pl?biblionumber=55066
29. Rahman FBA, Mustafa Z, Kharuddin AF.

Employing fuzzy Delphi technique to validate multiple Intelligence based instructional teaching module for preschool children. Southeast Asia Early Childhood Journal. 2021;10(1):62-71. Available from: http://doi.org/10.37134/saecj.vol10.1.6.2021

30. Arnkil A. Occupational safety and health in Finnish SME's: Occupational Safety and Health guidebook. 2019:41. Available from: https://www.theseus.fi/handle/10024/167391
31. Kabir G, Akhtar Hasin MA. Multi-criteria inventory classification through integration of fuzzy analytic hierarchy process and artificial neural network. International Journal of Industrial and Systems Engineering. 2013;14(1):74-103. Available from: http://doi.org/10.22214/ijraset.2018.5145
32. Shemsub C, Khecharanan N. Guidelines on safety management to the quality of life for employees in the workplace of thai refrigeration industry. Journal of the Association of Researchers. 2018;19(2):68-80. Available from: https://so04.tci-thaijo.org/index.php/jar/article/view/241134
33. Ruanngern S. Factors affecting employees' acceptance of environmental management system (ISO 14001) in Autoliv (Thailand) Ltd. 2012. Available from: http://library1.nida.ac.th/termpaper6/sd/2555/19767.pdf
34. Ruchakool P, Kulchatchai U, Sattayaprasert W. Motivation toward implementation of ISO 14001: A case study in Italian-Thai development public company Limited. Engineering Transactions. 2013;16(2):128-35. Available from: https://ph02.tci-thaijo.org/index.php/ET/article/view/245465/166393
35. Otitolaiye VO, Abd Aziz FS, Munauwar M, Omer F. The relationship between organizational safety culture and organization safety performance. The mediating role of safety management system. International Journal of Occupational Safety and Health. 2021;11(3):148-57. Available from: https://doi.org/10.3126/ijosh.v11i3.39766