GBMR
Global Business and Management Research: An International Journal
Vol. 17, No. 1 (2025)

Measuring Lean Culture – Validating a Research Instrument

Azim Azuan Osman
School of Technology Management & Logistics, Universiti Utara Malaysia

Syed Radzi Rahamaddulla*
Faculty of Industrial Management, Universiti Malaysia Pahang Al-Sultan Abdullah, Lebuh Persiaran Tun Khalil Yaakob, 26300 Gambang, Kuantan, Pahang, Malaysia

Email: syedradzi@umpsa.edu.my

Ahmad Nazif Noor Kamar
Faculty of Industrial Management, Universiti Malaysia Pahang Al-Sultan Abdullah, Lebuh Persiaran Tun Khalil Yaakob, 26300 Gambang, Kuantan, Pahang, Malaysia

Nurqamarina Norismail
Faculty of Industrial Management, Universiti Malaysia Pahang Al-Sultan Abdullah, Lebuh Persiaran Tun Khalil Yaakob, 26300 Gambang, Kuantan, Pahang, Malaysia

Norani Nordin
School of Technology Management and Logistics, Universiti Utara Malaysia

Abstract
Purpose: This study aims to present the procedure of validating a newly developed self-administered questionnaire for measuring Lean Culture in the manufacturing industry.
Design/methodology/approach: The self-administered questionnaire was developed based on a comprehensive literature review and validated by a panel of seven experts with extensive experience in Lean Manufacturing research and practice. Content validity was assessed using the content validity index and inter-rater agreement.
Findings: The results indicate that the self-administered questionnaire has high content validity, with all dimensions and items demonstrating I-CVI and S-CVI of 1.000, except for the Innovation dimension, which still met the minimum requirement. The inter-rater agreement results showed some variations between dimensions, suggesting that some items may need minor revisions to improve agreement among experts.
Research limitations: The instrument will need further validation using more advanced statistical techniques such as confirmatory factor analysis or confirmatory composite analysis.
Practical implications: The introduction and validation of a practical instrument to measure lean culture fills a significant gap in the quantitative assessment of lean culture's impact on lean transformation sustainability and smart technologies adoption in manufacturing settings.
Originality/value: This study addresses the absence of a practical and valid instrument to measure the level of lean culture, providing a tool that translates unobserved behavior into quantifiable data and contributing to the empirical evaluation of lean culture in manufacturing organizations.

Keywords: Lean transformation, Sustainable lean, Smart manufacturing, Scale development, Experts' validation

Introduction

Lean Manufacturing is a term coined to describe manufacturing without waste (Heizer et al., 2017). The transition from conventional manufacturing operations (e.g. mass, batch, and queue production) to Lean Manufacturing operations is known as Lean Transformation (Mann, 2015; Roth, 2011). The primary objective of Lean Transformation is the elimination of eight types of waste in manufacturing operations, summarized by the acronym DOWNTIME (Defects, Overproduction, Waiting times, Non-utilized talents, Transportations, Inventories, Motions, and Excess processing). However, Lean Transformation efforts by manufacturers worldwide have produced mixed results, even in highly industrialized nations such as the United Kingdom (UK) and the United States (US). In the US, 70% of manufacturers did not make significant progress (Tenescu & Teodorescu, 2014), over 50% failed (Kallage, 2006), and only 2% were truly successful and sustainable (Tenescu & Teodorescu, 2014). Similarly, only 10% of UK manufacturers were reported as successful lean practitioners (Bhasin & Burcher, 2006).

Mann (2003) suggested that Lean Culture is the missing link that connects the application of lean tools and techniques with the sustainable success of Lean Transformation. This notion was later supported by empirical evidence from studies such as Hines et al. (2008), Hogan (2009), Testani and Ramakrishnan (2010), Marchwinski (2014), and Sisson and Elshennawy (2015), which revealed that the formation of Lean Culture within successful lean organizations is crucial for sustaining Lean Transformation. However, these studies relied on qualitative evidence. On that account, research on Lean Culture still lacks quantitative evidence. Consequently, research on Lean Culture still lacks quantitative evidence. The absence of a practical research instrument for measuring Lean Culture complicates and hinders efforts to fill this knowledge gap. Therefore, there is a need to develop a practical, valid, and reliable research instrument to measure Lean Culture.

Furthermore, in the context of the evolving manufacturing landscape, the cultivation of a Lean Culture may extend its benefits beyond Lean Transformation itself. The dimensions of Lean Culture, such as effective communication, teamwork, problem solving and innovation, can also serve as foundation competencies for the adoption of Smart Manufacturing technologies (Gajdzik & Wolniak, 2022; Hernandez-de-Menendez et al., 2020; Jerman et al., 2020; Kipper et al., 2021). By fostering a mindset of adaptability, efficiency, and data-driven decision-making, a Lean Culture can enhance an organization's readiness to embrace the complexities and opportunities presented by Smart Manufacturing (Rahamaddulla et al., 2021).

The present study builds upon the authors' previous work (Osman et al., 2021), which introduced a self-administered questionnaire (SAQ) to measure Lean Culture. This paper focuses on validating this Lean Culture SAQ through expert review, contributing to both the understanding of Lean Culture and its potential role in facilitating the transition towards Smart Manufacturing.

Literature Review

A self-administered questionnaire (SAQ) is designed specifically to be completed by a respondent without the intervention of researchers to aid in answering questions (Lavrakas, 2008). The use of an SAQ as a research instrument is common and practical in studies aimed at measuring latent variables (abstract concepts) such as behaviour, attitudes, and hypothetical scenarios that cannot be assessed directly (Boateng et al., 2018). Lean Culture is considered an abstract concept as it includes all the elements and attributes required to implement and sustain

Lean Transformation initiatives (Alston, 2017). Therefore, an SAQ is an appropriate research instrument for measuring Lean Culture.

However, the real concept and meaning of Lean Culture are ambiguous. Recent literature reviews presented 23 different definitions of Lean Culture (Dorval et al., 2019). Different definitions of Lean Culture have led to different ideas for measuring this concept. Some researchers measured Lean Culture as a unidimensional (Iranmanesh et al., 2019; Welo & Ringen, 2015), while others measured it as a multidimensional construct (Jenei et al., 2014; Schröders & Cruz-Machado, 2015; Urban, 2015). Moreover, the number of dimensions proposed in previous studies varied from one study to another. For instance, Urban (2015) proposed five dimensions, while Jenei et al. (2014) introduced 12 dimensions of Lean Culture. However, there was no conceptual definition provided to describe each dimension or distinguish one dimension from another.

On the contrary, a conceptual definition is necessary to provide working knowledge of the latent variable under study, specify its boundaries, and ease the process of item generation and content validation (Boateng et al., 2018; Carpenter, 2018). Therefore, the present study conceptually defined Lean Culture as the ideal organizational (corporate) culture that fosters the success and sustainability of lean transformation in manufacturing organizations. Based on the authors' previous work (Osman et al., 2021), five dimensions were proposed to measure Lean Culture:

1. Organizational Environment: Reflects a non-blaming and process-driven working environment that inspires mutual trust and respect among organization members in a lean organization.
2. Effective Communication: The extent to which important information on the lean transformation journey is effectively transferred between organization members.
3. Teamwork: The extent to which lean transformation and problem resolution activities are handled in teams.
4. Problem Solving: The extent of problem resolution activities is carried out based on lean philosophy.
5. Innovation: Represents a work culture that welcomes new ideas and allows innovations to take place through experimentation and risk-taking.

Moreover, most previous studies that attempted to measure Lean Culture failed to report their validity evidence (Jenei et al., 2014; Pedersen-Rise & Haddud, 2016; Schröders & Cruz-Machado, 2015; Urban, 2015). This violation in instrument development research was also highlighted in Carpenter (2018) and Boateng et al. (2018). Carpenter (2018) cited that scale methodologists, including Rex Kline, James Conway, and Allen Huffcutt, argued that most measures had severe flaws, including those that were published in prestigious journals. Statistical and methodological decisions regarding SAQ item development were poor, resulting in questionable measures. Therefore, to atone for limitations identified in previous studies, this paper presented a validity assessment of a newly developed SAQ for measuring Lean Culture.

Method

The item development phase of a self-administered questionnaire (SAQ) involves two steps: item generation and content validation (Boateng et al., 2018). Step 1 was covered in the authors' previous work (see Osman et al. (2021)). Therefore, as a direct sequel to the study conducted in Osman et al. (2021), this paper focused on Step 2 (i.e. content validation). Content validation assesses whether the items adequately measure the concept of interest (Boateng et al., 2018). The two components of content validity are face validity and logical validity (Rubio et al., 2003). Face validity concerns whether a measurement item appears to reflect the content of the concept in question (Bryman, 2012). Meanwhile, logical validity involves a more rigorous process, such as using a panel of experts to determine the content representativeness and clarity of the items in an SAQ (Lynn, 1986; Rubio et al., 2003).

Albeit some scholars claim that content validation is a subjective assessment method (Flynn et al., 1999), Rubio et al. (2003) argue that it can be objectively assessed by calculating the content validity index (CVI). Therefore, this study utilized CVI calculation to validate the Lean Culture SAQ through objective measures. Additionally, reporting content-oriented evidence in this manner is a standard practice, as recognized by the American Educational Research Association, American Psychological Association, and National Council on Measurement in Education (American Educational Research Association et al., 2014).

CVI is determined by rating the content relevance of each item on an SAQ using a four-point ordinal scale: 1 = item is not representative, 2 = item needs major revisions, 3 = item needs minor revisions, and 4 = item is representative (Lynn, 1986). Then, CVI is calculated using the following formula:

$$CVI = \frac{n_r}{N_e} \quad (1)$$

In which the n_r represents the number of experts who rated the item as "representative" (score 3 and 4) and N_e is the total number of experts. Besides that, researchers are also recommended to calculate the item's inter-rater agreement (IRA) (Rubio et al., 2003). IRA is assessed to determine the extent to which the experts are reliable in their ratings using the following formula:

$$IRA = \frac{\sum n_a}{N_i} \quad (2)$$

in which the Σn_a represents the sum of individual items' agreement, and N_i is the total number of items for every dimension. Therefore, this study followed CVI reporting guidelines proposed by Rubio et al. (2003) to present the result of Lean Culture SAQ content validity assessment.

For this study, 15 experienced professionals well-versed in Lean Manufacturing research and/or hands-on practice were approached to form a panel of experts for the content validation procedure. Among the 15 experts, eight were from academia, holding or pursuing doctoral degrees in the Lean Manufacturing field. One of these academic experts specializes in scale development, and the authors specifically requested this expert to evaluate the scale's appropriateness and statistical potential of the proposed SAQ. The remaining experts included three lean consultants and four lean practitioners from manufacturing industries.

Initially, these experts were given a week to return the validation form. However, due to their hectic schedules, the data gathering procedure took almost a month to complete. Soft reminders through online texting and phone calls were sent once or twice every week to prompt the experts until they returned the form.

Findings

As a result, 11 out of 15 experts returned the validation form. However, four experts did not rate the items but provided comments on how to improve the research instrument. Therefore, only seven experts remained for the analyses. The four experts who responded but did not rate the items included two lean consultants, one practitioner from the automotive manufacturing industry and one senior lecturer. The demographic profile of seven experts who completed the validation form is presented in Table 1.

Table 1: Profile of Lean Experts

Expert Code	Gender	Qualification	Affiliation	Experience
Exp #1	Male	PhD	Associate Professor (public university)	10 years of experience in lean manufacturing research and lean industrial collaboration
Exp #2	Female	PhD	Senior lecturer (government-linked university)	8 years of experience in lean manufacturing research and lean industrial collaboration
Exp #3	Male	Masters	Lecturer (Polytechnic)	5 years of experience in lean manufacturing research and the winner of the public university's lean project competition
Exp #4	Female	Masters	Senior lecturer (Public university)	6 years of experience in lean manufacturing research and the winner of the public university's lean project competition
Exp #5	Male	Degree	Lean executive (Automotive industry)	10 years of experience as a practitioner
Exp #6	Male	Degree	Manufacturing engineer (Electrical & electronics industry)	9 years of experience as a practitioner
Exp #7	Male	Masters	Lean consultant (government agency)	5 years of experience as the lead consultant of lean projects

Lynn (1986) states that at least three experts are necessary for content validation. However, increasing the number of experts enhances the robustness of the ratings. Boateng et al. (2018) recommended having between five and seven experts, with the panel including individuals from diverse backgrounds. Specifically, the panel should consist of subject-matter researchers, methodologists, and professionals from the target population (Carpenter, 2018). In this study, the authors assembled a panel of seven experts, including academic lean scholars (subject-matter experts and methodologists), a lean consultant (subject-matter expert), and lean practitioners (experts from the target population). Thus, the study met the recommended number and diversity of experts as suggested in the literature. Table 2 presents the required values (rating scores) for the CVI and IRA calculations based on the previously quoted formula.

Table 2: Summary of lean experts' ratings

Item Code	Exp #1	Exp #2	Exp #3	Exp #4	Exp #5	Exp #6	Exp #7	n_r	n_a
OE01	4	4	4	4	4	4	4	7	7
OE02	4	4	4	4	4	4	4	7	7
OE03	4	4	4	3	4	4	4	7	6
OE04	4	4	4	3	4	4	4	7	6
OE05	4	4	4	4	4	4	4	7	7
OE06	4	4	4	4	4	4	4	7	7
OE07	4	4	4	4	4	4	4	7	7
EC01	4	4	3	4	4	4	4	7	6
EC02	4	4	4	4	4	4	4	7	7
EC03	4	4	4	4	4	4	4	7	7
EC04	4	4	4	4	4	4	4	7	7
EC05	4	4	4	4	4	4	4	7	7
EC06	4	4	4	4	4	4	4	7	7
EC07	4	4	4	4	4	4	4	7	7
EC08	4	4	4	4	4	4	4	7	7
TW01	4	4	4	4	4	4	4	7	7
TW02	4	4	4	4	4	4	4	7	7
TW03	4	4	4	4	4	4	4	7	7
TW04	4	4	4	4	4	4	4	7	7
TW05	4	4	4	4	4	4	4	7	7
TW06	4	4	4	3	4	4	4	7	6
TW07	4	4	4	4	4	4	4	7	7
PS01	4	4	4	4	4	4	4	7	7
PS02	4	4	4	4	3	4	4	7	6
PS03	4	4	4	4	4	4	4	7	7
PS04	4	4	4	4	4	4	4	7	7
PS05	4	4	4	4	4	4	4	7	7
PS06	4	4	4	4	4	4	4	7	7
PS07	4	4	4	3	4	4	4	7	6
PS08	4	4	4	3	4	4	4	7	6
IV01	4	4	4	3	2	4	4	6	5
IV02	4	4	4	3	4	4	4	7	6
IV03	4	4	4	4	2	4	4	6	6
IV04	4	4	4	4	2	4	4	6	6
IV05	4	4	4	4	2	4	4	6	6
IV06	4	4	4	4	4	4	4	7	7

Note. *Nr* = number of experts who rated 3 or 4, n_a = individual item's agreement

As recommended by Rubio et al. (2003), CVI and IRA were calculated at both the item-level and dimension-level. To avoid confusion and properly distinguish between the two, Polit and Beck (2006) suggested using I-CVI for the content validity index of individual items and S-CVI for the content validity index of the entire dimension. Similarly, this study used the acronyms I-IRA and S-IRA to represent item-level and scale-level inter-rater agreement, respectively. According to Davis (1992), a CVI of 0.80 is sufficient to establish content validity for an SAQ. Similarly, an IRA of 0.80 indicates that the measurement items in an SAQ have acceptable reliability (Lynn, 1986). All results are reported in Table 3.

Table 3: CVI and IRA results

Dimensions	Item Code	n_r	I-CVI	S-CVI	n_a	I-IRA	S-IRA
Organizational Environment	OE01	7	1.000	1.000	7	1.000	0.959
	OE02	7	1.000		7	1.000	
	OE03	7	1.000		6	0.857	
	OE04	7	1.000		6	0.857	
	OE05	7	1.000		7	1.000	
	OE06	7	1.000		7	1.000	
	OE07	7	1.000		7	1.000	
Effective Communications	EC01	7	1.000	1.000	6	0.857	0.982
	EC02	7	1.000		7	1.000	
	EC03	7	1.000		7	1.000	
	EC04	7	1.000		7	1.000	
	EC05	7	1.000		7	1.000	
	EC06	7	1.000		7	1.000	
	EC07	7	1.000		7	1.000	
	EC08	7	1.000		7	1.000	
Teamwork	TW01	7	1.000	1.000	7	1.000	0.980
	TW02	7	1.000		7	1.000	
	TW03	7	1.000		7	1.000	
	TW04	7	1.000		7	1.000	
	TW05	7	1.000		7	1.000	
	TW06	7	1.000		6	0.857	
	TW07	7	1.000		7	1.000	
Problem Solving	PS01	7	1.000	1.000	7	1.000	0.959
	PS02	7	1.000		6	0.857	
	PS03	7	1.000		7	1.000	
	PS04	7	1.000		7	1.000	
	PS05	7	1.000		7	1.000	
	PS06	7	1.000		7	1.000	
	PS07	7	1.000		6	0.857	
	PS08	7	1.000		6	0.857	
Innovation	IV01	6	0.857	0.905	5	0.714	0.857
	IV02	7	1.000		6	0.857	
	IV03	6	0.857		6	0.857	
	IV04	6	0.857		6	0.857	
	IV05	6	0.857		6	0.857	
	IV06	7	1.000		7	1.000	

CVI calculations showed that all dimensions and items had I-CVI and S-CVI of 1.000, except for the Innovation dimension. I-CVI for Innovation items ranged from 0.857 to 1.00. Four out of seven items had an I-CVI of 0.857, while the remaining three items had an I-CVI of 1.000 which resulting in an S-CVI of 0.905. Despite this, these results met the minimum requirement for content validity evidence. On the other hand, IRA results varied between dimensions, ranging from 0.741 to 1.000 for I-IRA and 0.816 to 0.982 for S-IRA. The lower IRA ratings for the Innovation dimension indicated that at least one expert rated the item differently from the others, and none of the items received 100 percent agreement (consensus) from the experts. IV01 had the lowest I-IRA, as Exp#4 rated the items with a score of 3 (items need minor revisions), while Exp#5 rated it with a score of 2 (item needs major revisions). Exp#4 also posited a written comment regarding items IV01 and IV02 as follows: “Please change the wordings, ‘employees at all positions’ to ‘all employees’,”. Meanwhile, Exp#5 expressed the following argument: “It is better to ask how employees introduce new ideas, i.e. steps from introducing new ideas until that idea is implemented”. Besides that, Exp#5 also rated IV03, IV04 and IV05 with a score of 2, along with the following criticisms: “Lean-related activities should not only involve production workers, but they demand commitment from both horizontal (across departments) and vertical (hierarchical level) directions”.

Despite these critiques, the authors decided not to make any changes to the questionnaire items. In the authors' defence, the present SAQ had been sent to a proofreader (a 10-year experienced English course instructor) to check on the choice of words and meaning of each sentence before it was distributed to a panel of experts. Therefore, there should be no wording issue to argue with. Meanwhile, although lean implementation indeed requires participation from all employees (across departments and hierarchical levels), production workers are the backbone of a manufacturing organization. Hence, innovations start from a small setting (production or manufacturing department) and may not progress to a bigger setting (e.g. human resource, supply chain, and other business functions) just yet for new lean adopters. This is the reason why lean scholars have introduced jargon such as Lean Manufacturing, Lean Production, and Lean Enterprise to describe how extensively lean principles are applied in manufacturing settings (Osman et al., 2019). The current SAQ is meant to measure Lean Culture in the production or manufacturing department, so that it is appropriate for all lean adopters regardless of their lean maturity level (i.e. manufacturing level, production level, or enterprise level).

Discussion and Conclusions

Overall, this paper presented the content validation assessment, an essential step in developing measurement items for an SAQ. A panel of seven experts, including lean academic scholars, lean consultants, and lean practitioners, validated the proposed measures of Lean Culture. This diverse panel critiqued the measures to determine the representativeness and clarity of the items. Utilizing experts from various backgrounds increased the robustness of the assessment, as the authors received feedback from diverse perspectives to improve the research instrument. Although some scholars consider content validation a subjective assessment, using the CVI method enhances its objectivity.

The outcome of this study is expected to assist practitioners in properly assessing their organizational culture relative to the ideal culture that fosters the sustainability of Lean Transformation in their organizations. This assessment would enable them to persistently pursue Lean Transformation and achieve operational excellence. From an academic perspective, this research instrument would allow other researchers to investigate manufacturers' ability to shift from ordinary corporate culture to Lean Culture. Furthermore, this SAQ would serve as the groundwork for future studies to examine the effect of Lean Culture formation on the sustainability of Lean Transformation.

Moreover, the validation of this Lean Culture SAQ carries implications beyond the realm of Lean Transformation. By providing a tool to measure the extent to which Lean principles and practices are embedded within an organization, this SAQ can also contribute to assessing an organization's readiness for Smart Manufacturing adoption. The cultivation of a Lean Culture, with its emphasis on effective communication, problem solving, teamwork, and innovation can create a fertile environment for the successful integration of Smart Manufacturing technologies (Gajdzik & Wolniak, 2022; Hernandez-de-Menendez et al., 2020; Jerman et al., 2020; Kipper et al., 2021). Future research can build upon this foundation by exploring the relationship between Lean Culture and Smart Manufacturing adoption readiness, further elucidating the role of Lean Culture in navigating the complexities of the digital transformation in manufacturing.

Acknowledgement
This work was supported by the Universiti Malaysia Pahang Al-Sultan Abdullah RDU [RDU230307].

References

Alston, F. (2017). *Lean Implementation Applications and Hidden Costs*. CRC Press.

American Educational Research Association, A. E. R. A., American Psychological Association, A. P. A., & National Council on Measurement in Education, N. C. M. E. (2014). *Standards for educational and psychological testing*. American Education Research Association.

Bhasin, S., & Burcher, P. (2006). Lean is viewed as a philosophy. *Journal of Manufacturing Technology Management*, *17*(1), 56-72. https://doi.org/10.1108/17410380610639506

Boateng, G. O., Neilands, T. B., Frongillo, E. A., Melgar-Quiñonez, H. R., & Young, S. L. (2018). Best practices for developing and validating scales for health, social, and behavioral research: A primer. *Frontiers in Public Health*, *6*(149), 1-18. https://doi.org/10.3389/fpubh.2018.00149

Bryman, A. (2012). *Social research methods* (4th ed.). Oxford University Press.

Carpenter, S. (2018). Ten steps in scale development and reporting: A guide for researchers. *Communication Methods and Measures*, *12*(1), 25-44. https://doi.org/10.1080/19312458.2017.1396583

Davis, L. L. (1992). Instrument review: Getting the most from a panel of experts. *Applied Nursing Research*, *5*(4), 194-197. https://doi.org/10.1016/S0897-1897(05)80008-4

Dorval, M., Jobin, M.-H., & Benomar, N. (2019). Lean culture: A comprehensive systematic literature review. *International Journal of Productivity and Performance Management*, *68*(5), 920-937. https://doi.org/10.1108/IJPPM-03-2018-0087

Flynn, B. B., Schroeder, R. G., & Flynn, E. J. (1999). World-class manufacturing: an investigation of Hayes and Wheelwright's foundation. *Journal of Operations Management*, *17*(3), 249-269. https://doi.org/10.1016/S0272-6963(98)00050-3

Gajdzik, B., & Wolniak, R. (2022). Smart production workers in terms of creativity and innovation: The implication for open innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(2), 68. https://www.mdpi.com/2199-8531/8/2/68

Heizer, J., Render, B., & Munson, C. (2017). *Operations management: Sustainability and supply chain management* (12th ed.). Pearson Education, Inc.

Hernandez-de-Menendez, M., Morales-Menendez, R., Escobar, C. A., & McGovern, M. (2020). Competencies for Industry 4.0. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, *14*(4), 1511-1524. https://doi.org/10.1007/s12008-020-00716-2

Hines, P., Found, P. A., Griffiths, G., & Harrison, R. (2008). *Staying lean: Thriving, not just surviving*. Lean Enterprise Research Centre, Cardiff University. https://orca.cf.ac.uk/52764/1/stayinglean.pdf

Hogan, B. J. (2009, December 1st, 2016). Sustaining a lean culture. *Manufacturing Engineering Magazine*, *143*(5), 71-76. http://advancedmanufacturing.org/sustaining-lean-culture/

Iranmanesh, M., Zailani, S., Hyun, S. S., Ali, M. H., & Kim, K. (2019). Impact of lean manufacturing practices on firms' sustainable performance: Lean culture as a moderator. *Sustainability*, *11*(4), 1112. https://doi.org/10.3390/su11041112

Jenei, I., Toarniczky, A., Losonci, D., & Imre, N. (2014). Lean organisational culture - development and testing of a measurement tool. *European Journal of Cross-Cultural Competence and Management*, *3*(3-4), 257-278. https://doi.org/10.1504/ejccm.2015.071961

Jerman, A., Pejić Bach, M., & Aleksić, A. (2020). Transformation towards smart factory system: Examining new job profiles and competencies. *Systems Research and Behavioral Science*, *37*(2), 388-402. https://doi.org/https://doi.org/10.1002/sres.2657

Kallage, R. G. (2006). Lean implementation failures. *Stamping Journal*, *18*(7), 26-29. http://www.thefabricator.com/article/shopmanagement/lean-implementation-failures

Kipper, L. M., Iepsen, S., Dal Forno, A. J., Frozza, R., Furstenau, L., Agnes, J., & Cossul, D. (2021). Scientific mapping to identify competencies required by Industry 4.0. *Technology in Society*, *64*, 101454. https://doi.org/https://doi.org/10.1016/j.techsoc.2020.101454

Lavrakas, P. (2008). Self-administered questionnaire. In P. Lavrakas (Ed.), *Encyclopedia of survey research methods* (Vol. 1 & 2). Thousand Oaks, CA: SAGE Publications, Inc.

Lynn, M. R. (1986). Determination and quantification of content validity. *Nursing Research*, *35*(6), 382-385. https://doi.org/10.1097/00006199-198611000-00017

Mann, D. W. (2003). The case for lean culture: Sustain the gains from your lean conversion. *Target: International Journal of Translation Studies*, *19*(4). https://www.ame.org/target/articles/2003/case-lean-culture

Mann, D. W. (2015). *Creating a lean culture: Tools to sustain lean conversions* (3rd ed.). CRC Press.

Marchwinski, C. (2014). *Sustain your lean business system with a "Golden Triangle"*. Lean Enterprise Institute. Retrieved Dec 1st from http://www.lean.org/common/display/?o=2592

Osman, A. A., Nordin, N., & Abd. Rahman, M. F. (2021). Measuring lean culture: Designing a research instrument. *Journal of Modern Manufacturing Systems and Technology*, *5*(1), 7-17. https://doi.org/10.15282/jmmst.v5i1.5821

Osman, A. A., Othman, A. A., & Abdul Rahim, M. K. I. (2019). A review of lean application in manufacturing environment: Definitions and terminologies. *Journal of Technology and Operations Management*, *14*(2), 28-45. https://doi.org/10.32890/jtom2019.14.2.8716

Pedersen-Rise, O., & Haddud, A. (2016). Exploring lean culture challenges in a small family-owned manufacturing company: A case study from Norway. *International Journal of Lean Enterprise Research*, *2*(1), 1-25. https://doi.org/10.1504/ijler.2016.078247

Polit, D. F., & Beck, C. T. (2006). The content validity index: Are you sure you know what's being reported? Critique and recommendations. *Research in Nursing and Health*, *29*(5), 489-497. https://doi.org/10.1002/nur.20147

Rahamaddulla, S. R. B., Leman, Z., Baharudin, B. T. H. T. B., & Ahmad, S. A. (2021). Conceptualizing Smart Manufacturing Readiness-Maturity Model for Small and Medium Enterprise (SME) in Malaysia. *Sustainability*, *13*(17), 9793. https://www.mdpi.com/2071-1050/13/17/9793

Roth, G. (2011). Sustaining lean transformation through growth and positive organizational change. *Journal of Enterprise Transformation*, *1*(2), 119-146. https://doi.org/10.1080/19488289.2011.579228

Rubio, D. M., Berg-Weger, M., Tebb, S. S., Lee, E. S., & Rauch, S. (2003). Objectifying content validity: Conducting a content validity study in social work research. *Social Work Research*, *27*(2), 94-104. https://doi.org/10.1093/swr/27.2.94

Schröders, T., & Cruz-Machado, V. (2015). Sustainable lean implementation: An assessment tool. Proceedings of the Ninth International Conference on Management Science and Engineering Management, Advances in Intelligent Systems and Computing, Berlin Heidelberg.

Sisson, J. A., & Elshennawy, A. (2015). Achieving success with lean. *International Journal of Lean Six Sigma*, *6*(3), 263-280. https://doi.org/10.1108/IJLSS-07-2014-0024

Tenescu, A., & Teodorescu, M. (2014). Lean manufacturing: A concept towards sustainable management. *Communications in Applied Sciences*, *2*(1), 97. https://infinitypress.info/index.php/cas/article/download/761/340

Testani, M. V., & Ramakrishnan, S. (2010). The role of leadership in sustaining a lean transformation. Proceedings of the 2010 Industrial Engineering Research Conference (IeRC), Springfield, MO.

Urban, W. (2015). The lean management maturity self-assessment tool is based on organizational culture diagnosis. *Procedia - Social and Behavioral Sciences*, *213*, 728-733. https://doi.org/10.1016/j.sbspro.2015.11.527

Welo, T., & Ringen, G. (2015). Investigating lean development practices in SE companies: A comparative study between sectors. *Procedia Computer Science*, *44*, 234-243. https://doi.org/10.1016/j.procs.2015.03.056