7th European Conference on Industrial Engineering and Operations Management
Augsburg, Germany, July 16-18, 2024
Publisher: IEOM Society International, USA DOI: 10.46254/EU07.20240087
Published: July 16, 2024

The Impact of the Measuring Scale on Research Outcomes

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Abstract

The choice of measuring scales and their nomenclatures are critical but should be influenced by the research objectives. In this research, adopting the 'content analysis study' approach, the 'mirror image' variant of the Likert scale, was used to critique the results from earlier research that used the standard Likert scale 1-5, where each unit was allocated linear positive integers. The focus was to evaluate the impact on the results of consensus-reaching processes (CRPs) used for addressing a group decision-making (GDM) problem among professionals in the built environment and can be adapted for use in the implementation of AI in conservative industries. The two measuring scales were identified as Scales 1 and 2 where Scale 1 is the standard Likert scale and Scale 2 is the mirror image scale. The results revealed that the outcome of Scale 1 progressively reduced the chosen factors, from twenty-one to thirteen and twelve. Similarly, the second scale, drastically reduced the same factors to nine and eight respectively. The emerging twelve factors from Scale 1 aptly represented the interests of the different professionals who participated in the exercise, compared to the eight factors from Scale 2. Thus, the former provides more suitable solutions to the GDM problem.

Keywords
Consensus reaching processes, Group decision-making, Measuring scales, Professionals, Research objectives.

1. Introduction
In earlier research, presented in different detail at some conferences, the authors (Ogbeifun, et al., 2023; Ogbeifun and Pretorius, 2023) explored what the built environment professionals considered as the critical quality characteristics that should be evident, in what can be classified as an excellent building design, making the edifice suitable and fit for purpose throughout its lifecycle. The panel of built environment professionals comprising architects, builders, contractors, engineers, estate valuers, and quantity surveyors. Adopting the classical Delphi technique, twenty-one characteristics were suggested in the first round of the exercise. Using the Likert scale of 1-5, the twenty-one factors were reduced to twelve, after two successive iterations. The focus of this research is on using a different variant of the Likert scale, the 'mirror image', and comparing the results for addressing a group decision-making (GDM) problem and possible adaptation to the introduction of the use of artificial intelligence (AI) in conservative industries, through the contextual use of the principles of consensus-reaching processes (Labella, et al., 2018).

Consensus-reaching processes (CRPs) are the attempt to reach a mutual agreement in a relatively free atmosphere, where each participant makes an objective contribution to the solution of the common problem facing the group (Labella, et al., 2018). To achieve consensus in GDM, involving multiple individuals who are experts with set ideals, attitudes, opinions, and preferred solutions to the problem facing the group, can be a daunting task (Labella, et al., 2018). GDM problems that require the joint participation of multiple experts exist in diverse areas of human endeavor such as management, engineering, politics and more (Kwong et al., 2011; Morais and De Almeida, 2012). They can be resolved through a homogenous or heterogenous group of participants (Kou and Peng, 2018). In this scenario, consensus is reached through the dynamic marriage between the individual decision matrix and the group decision matrix in successive iteration processes, using a predetermined benchmark to adjust the individual decision and select the best alternatives (Rodriguez et al., 2018). Depending on the nature of the GDM problems, the number of participants could be in several hundreds or thousands if the problem and emerging decisions affect large proportions of society (Rodriguez et al., 2018). The challenges associated with large-scale group decision-making (LS-GDM), revolve around the effective management of the large number of participants and the large number of ideas, options, or alternative solutions to choose from. In this regard, achieving consensus demands several rounds of successive iterations of information and feedback, which are repetitive, and slow and usually result in hesitations or the high attrition of participants (Palomares, et al., 2014; Rodriguez et al., 2018).

Reducing the negative effects of individuals with strong personal and overbearing characters, disagreements, and coercion in addressing GDM problems necessitates the adoption of consensus-reaching processes (CRPs). CRPs aim to help decision-makers achieve mutual agreement in finding solutions to the group's problem (Hall, et al., 2016; Zhang et al., 2019). It involves multi-stage negotiation processes or iterative rounds until the areas of disagreement are reduced to the barest minimum and equilibrium is achieved in core value areas of the group (Cullerton, et al., 2019; Perez, et al., 2018). In a typical CRP, individuals or experts discuss and modify their preferences to reach a collective agreement before making decisions (Labella, et al., 2018). Several research approaches have been developed for achieving consensus while dealing with GDM problems. Some of the approaches may involve face-to-face interactions such as focus group (FG) sessions (Breen, 2006; Brown, 2015), committee settings (Rusinowska et al., 2007; Levino and Morals, 2012), or non-face-to-face approaches, such as the Delphi technique (Flecher and Marchildon, 2014; Brandy, 2015; Ogbeifun, et al., 2017). Some of the advantages of adopting the Delphi technique include time and cost-effectiveness, involving participants from wide geographical locations, participants being purposively selected, the anonymity of contribution, and the result being the product sourced from knowledgeable individuals and therefore different from general survey results.

2. Literature review

2.1 The Delphi Technique

The Delphi technique as a consensus-building tool is useful where participants are spread across areas of diverse geographical settings. The heterogeneity and anonymity of the participants are critical in achieving the research objectives (Ogbeifun, et al., 2016). There are different classifications of the Delphi technique, which include the classical Delphi, decision-making, and policy Delphi (Meskell, et al., 2014). The Delphi process revolves around the research coordinator and commences from the recruitment of participants, collation, iteration of results, and recycling results from each round of the exercise to the participants for further interaction until equilibrium is reached and the results are accepted as the consensus opinion of the group. The participants, commonly referred to as knowledgeable persons or experts in the subject of the research, are purposively selected after satisfying the set pre-qualification criteria (Hasson and Keeney, 2011; Brandy, 2015). In a typical Delphi exercise, the number of participants may be as small as three and as large as possible. However, the panel size of eight members is an acceptable minimum (Hallowell and Gambatese, 2010). Efforts should be made at the beginning of the exercise, to recruit more participants than the 'preferred group size' to reduce the negative effects of attrition (Donohoe and Needham, 2009; Helms, et al., 2017). Generally, consensus is said to have occurred when there is convergence of opinion, the participants are no longer modifying their earlier decisions, or the areas of agreement are higher than seventy percent of the suggested solution to the research question. Consensus may be achieved within a few rounds or after several rounds of iterations (Flecher and Marchildon, 2014; Ogbeifun, et al., 2017).

2.2 The Likert scales

The Likert scale is a psychometric scale commonly used in survey questionnaires. The rating scale ranges from high to low or best to worst, using odd or even numbers like four, five, six to eleven (Allen and Seaman, 2007; Pimentel, 2010). However, the most common range is five ordered response levels, but some suggest using seven or nine levels. The format of a typical five-level Likert item is: 1. Strongly Disagree, 2. Disagree, 3. Neither Agree nor Disagree (undecided or neutral), 4. Agree, 5. Strongly Agree. In other scenarios, the scale 1-5 may assume positive integers, in ascending order from 1 to 5 or adopt the mirror image, where the middle number in the scale assumes a zero numeral (Pimentel, 2010).

Interestingly, the Likert scale is sometimes difficult to use for measuring items requiring definite responses to some very personal issues, except provided within the defined range of high and low. For example, what is your salary? Chimi and Russell, (2009), opined that such questions are easier if there is a range between A and B, less than X or greater than Y. Furthermore, Ogden and Lo, (2012), observed that data from Likert scales can be problematic, subject to faulty interpretation and application to real-life study problematic, especially if the participants are not purposively selected. Unless there is a pre-qualification exercise before enlisting participants in research using the Likert scale, especially the linearly positive integers, many of the participants may not respond objectively. Consequently, their response could negatively impact the results. This is of concern when a great proportion of the participants identify with the middle figure in the Scale, 3 in the case of a 1-5 scale. Respondents to an odd number Likert scale exercise may use the middle point response as moderate standing or as a 'dumping ground' for unsure or non-applicable response (Kulla, et al., 2008). Baka, et al., (2012), identified many other terminologies used to describe the middle point on a Likert scale, including 'undecided' and 'uncertain' or 'not sure', noting that the middle position indicates neutrality. One of the most probable reasons why participants may choose the middle response, even where there are options of 'I don't know', could be to hide their ignorance, choosing to sit on the fence as the safest approach ((Baka, et al., 2012; Murray et al., 2916). In practice, the value allocated to the middle position plays a significant role in achieving the purpose of the research exercise.

In a research exercise requiring information for a short-term or precise decision, it may be suggested to allocate zero to the middle position to achieve the 'mirror image' of the Likert scale. Then no participant is sitting on the fence and respondents must align with the positive or negative positions and whatever suggestions are in the middle position will be treated as zero. When collecting information for a long-term decision, or in a participative decision-making process, which requires the effective buy-in of most of the stakeholders, a positive integer allocated to the middle position will allow for several rounds of iterative information gathering, till equilibrium is achieved (Kistowski, et al., 2015). Here, the coordinator will guide the exercise, encouraging the participants to aim at 'fewer is better' in their suggestions (Walser, et al., 2019). In a GDM problem-solving process, the choice of the measuring scale and benchmark are critical.

The choice of benchmark is critical in CRP sessions so that the emerging solution to the GDM problem will create harmony and not more problems (Piotrowski, et al., 2023). The benchmark should not be too high or too low. A low benchmark would mean repeating the circle of data collection and iteration many times, with minimal changes in the information set. This may lead to frustration and lack of interest and result in high attrition. Conversely, if the benchmark is too high, consensus may be reached too soon, without effectively capturing the opinions of participants (Hall, et al., 2016; Zhang et al., 2019). Decisions reached too quickly might alienate some participants from owning the decision, resulting in descensions and the possible breakdown of the problem-resolution process (Perez, et al., 2018). It is important, therefore, to choose a moderate-level benchmark, to provide sufficient opportunities for participants to interact with the subject, review their submissions along with the thoughtful suggestions from other participants, to enhance reaching an equilibrium of ideas for a mutual decision (Fink-Hafner, et al., 2019). The process of executing a research exercise on consensus-reaching process (CRP) for solving a GDM problem is described in the next section.

3. Research method

The preceding research that gave birth to the current one (Ogbeifun, et al., 2023; Ogbeifun and Pretorius, 2023), adopted the Classical Delphi technique, as a tool for consensus building to ameliorate the challenges of managing a difficult face-to-face scenario with a heterogeneous group of professionals in the built environment industry (Brandy, 2015; Ogbeifun, et al., 2017). The exercise used the Likert scale 1-5 that assumed the linear positive integers. After three rounds of data collection, the twenty-one factors were reduced to twelve. The importance of the current research is to analyze the results of the previous research using a variant scale of the Likert scale 1-5, by adopting the concept of mirror imaging. In this regard, the nomenclature of Scales 1 and 2 bear negative integers, 3 bears the zero integer, while 4 and 5 bear positive integers. It thus avoids the tilting effects of the middle point, allowing participants to align positively or negatively with each factor of the research (Robertson, et al., 2017). This tool is used in the context of the 'Content Analysis Study' of the previous research results (Dumay and Cai, 2015; Wilson, 2016). The objective is to evaluate the impact of the scale used in the analysis on the research result, especially when conducting CRPs for addressing a GDM problem. The research process, results, and discussions follow hereafter.

4. Results: Analysis with Alternative Scale

In the previous research (Ogbeifun, et al., 2023; Ogbeifun and Pretorius, 2023), the Likert scale 1-5 assumed positive integers, in ascending order from 1-5 and the arithmetic average was chosen for the analysis. In this exercise, the variant scale, which is the concept of 'mirror imaging', was used (Dilks, et al., 2011). Here the integers 1-5 are as follows: 1 = very low, 2 = low, 3 = neutral, 4 = high and 5 = very high and their dynamic equivalence are: 1 = -4, 2 = -2, 3 = 0, 4 = +2 and 5 = +4.

In the computation of the scores, it is first assumed that all participants rated each question as 'very high', with a maximum of 4 points (Pasipatorwa, et al., 2022). When this is multiplied by the total number of participants (4 x 22, in round 2), it provides a weighted score of 88. Therefore, the weighted average for each factor is obtained by dividing the arithmetic sum of the score for each item by the weighted score, as shown in Equation 1.

Weighted score for factor:

$$X = [-4xn_1 - 2xn_2 + 0xn_3 + 2xn_4 + 4xn_5]/\text{Weighted score} \quad (1)$$

Where n_1 represents the number of participants who rated the factor as 1, similarly, n_2, n_3, n_4, and n_5, represent the number of participants who rated the factor accordingly.

Example factor 1.

Weighted score = [(-2 x 1) + 0 x 9 + 2 x 5 + 4 x 5]/88
= [-2 + 0 + 10 + 20]/88
= 28/88
= 0.32

Thus, the weighted score for each of the 21 factors was calculated. The weighted score of 0.5, was set as the benchmark for consensus. After analysis, nine items satisfied the benchmark, compared to thirteen items in the first exercise, using Scale 1. The factors that did not meet the benchmark are marked in red, under Scales 1 and 2 respectively, as shown in Table 1.

Table 1. Results of the analysis of round 2, using Scales 1 & 2.

Scale 1			**Scale 2**		
S/ No	***Factors***	***Average score***	***S/ No***	***Factors***	***Weighted score***
1	Aesthetics	3.64	1	Aesthetics	0.32
2	Buildability	4.41	2	Buildability	0.71
3	Climate	2.82	3	Climate	0.09
4	Communication	2.55	4	Communication	0.16
5	Concept	3.64	5	Concept	0.25
6	Conformity to code	4.27	6	Conformity to code	0.64
7	Convenience	3.41	7	Convenience	0.21
8	Cost	4.27	8	Cost	0.64
9	Culture and religion	2.41	9	Culture and religion	0.30
10	Design tools	3.36	10	Design tools	0.18
11	Environmentally friendly	4.05	11	Environmentally friendly	0.52
12	Experience	3.82	12	Experience	0.41
13	Flexibility for adaptation	2.95	13	Flexibility for adaptation	0.30
14	Functionality	4.18	14	Functionality	0.66
15	Location	3.09	15	Location	0.11
16	Maintenance	4.36	16	Maintenance	0.68
17	Materials	4.23	17	Materials	0.61
18	Security	3.59	18	Security	0.30
19	Site condition	3.45	19	Site condition	0.26
20	Strength	3.77	20	Strength	0.52
21	Sustainable	3.91	21	Sustainable	0.60

Similarly, the analysis was conducted on the thirteen factors, using Scale 2. While twelve items met the benchmark, using Scale 1, eight items met the benchmark using Scale 2, as shown in Table 2.

Table 2. Results of the analysis of round 3, using Scales 1 & 2.

Scale1			**Scale 2**		
S/ No	***Factors***	***Average score***	***S/ No***	***Factors***	***Weighted score***
1	Aesthetics	3.75	1	Aesthetics	0.38
2	Buildability	4.88	2	Buildability	0.94
3	Concept	3.69	3	Concept	0.34
4	Conformity to code	4.19	4	Conformity to code	0.72
5	Cost	4.44	5	Cost	0.72
6	Environmentally friendly	3.69	6	Environmentally friendly	0.47
7	Experience	3.63	7	Experience	0.31
8	Functionality	4.63	8	Functionality	0.81
9	Maintenance	4.38	9	Maintenance	0.68
10	Materials	4.50	10	Materials	0.75
11	Security	3.31	11	Security	0,16
12	Strength or stability	4.19	12	Strength or stability	0.59
13	Sustainable	3.69	13	Sustainable	0.63

Table 3 provides the results of the analysis, showing twelve and eight factors, using Scales 1 and 2, respectively. The factors are arranged chronologically, based on their score.

Table 3. Factors arranged in order of importance

Scale 1			**Scale 2**		
S/ No	***Factors***	***Average score***	***S/ No***	***Factors***	***Weighted score***
1	Buildability	4.88	1	Buildability	0.94
2	Functionality	4.63	2	Functionality	0.81
3	Materials	4.50	3	Materials	0.75
4	Cost	4.44	4	Cost	0.72
5	Maintenance	4.38	5	Conformity to code	0.72
6	Conformity to code	4.19	6	Maintenance	0.68
7	Strength or stability	4.19	7	Sustainable	0.63
8	Aesthetics	3.75	8	Strength or stability	0.59
9	Concept	3.69			
10	Environmentally friendly	3.69			
11	Sustainable	3.69			
12	Experience	3.63			

A closer examination of the emerging factors shows that the factors from Scale 1 are more encompassing, fairly representing the interests of the professionals that participated in finding solutions to the GDM problem. In contrast, the results of Scale 2, could equally be used in solving a GDM problem in scenarios where there is the need to streamline many options to the few most suitable, economical, and cost-effective solutions, which allows for the most prudent use of available resources.

5. Discussion of findings

A critical look at the results presented above raises two fundamental issues for detailed discussion. The first is the impact of the measuring scale and benchmark on CRPs in addressing GDM problems. Secondly, accepting the solution to a GDM problem amicably without professional rancor.

5.1 The Impact of Measuring Scale and Benchmark in a Consensus-building Process

As demonstrated in this research, the different measuring scales and the chosen benchmarks had overarching effects on the resulting quality factors developed from the exercise. Furthermore, the results from each scale have a significant influence on the participation of the team members in the exercise. Remember, the participants in this research are a heterogeneous team of professionals with set ideals, professional training, disciplines, and an uncompromising standing in building development. However, the objectives of the research were to help all the team members look beyond their professional preferences, into the future of the proposed edifice, as well as encourage the cultivation of the idea of harnessing the strength of other members of the team to develop a resilient and functional edifice. Therefore, managing relationships against such a background requires some tact, diplomacy, and time for progressive interactions and reasoning to ensure the effective 'buy-in' of all participants (French-Brown and Crow, 2015).

The results of the analysis of Table 1 are shown in Table 2. The outcome, using Scale 1, provided a set of factors that captured the interest of the heterogeneous participants of the research exercise and encouraged their continued participation in the exercise (Hall et al., 2016). Conversely, Scale 2 presented a sharp contrast. As shown in Table 2, aesthetics and concept, the hallmarks of the architects, were eliminated. Similarly, strength or stability and the interest of structural engineers were relegated to the lowest level. This scenario in a typical CRP being used to address a GDM problem can discourage these professionals from continuing their participation in the exercise (Labella, et al., 2018). However, some key considerations in the choice of scales and benchmarks include the following.

i. The scale, low or high benchmarks, could produce slow or fast results, but the outcome may not be acceptable to the constituencies of the GDM setting or suitable solutions for addressing the GDM problem (Kistrowski, et al., 2015; Piotrowski, et al., 2023).

ii. An appropriate scale and moderate benchmark, which allows for progressive interactions before a final decision, holds the potential to produce more acceptable solutions to GDM problems (Perez, et al., 2018).

iii. However, a mirror image scale and high benchmark are useful when it is necessary to streamline options to the barest minimum, identify the capsule suggestion(s) with far-reaching effects, to guide the effective use of scarce resources. They are equally useful for gathering information for preliminary design, or a situation that requires a precise decision at short notice (Pimentel, 2010).

Therefore, in a typical GDM problem, including the adoption of AI or new technologies, the choice of scale and benchmark should allow ample opportunities for the participants to interact with the problem, evaluate the suggestions of other participants, buy-in, and achieve mutual equilibrium, in a win-win scenario.

5.2 Accepting the Solution to a GDM Problem

Ordinarily, if the subject of this research was discussed in a face-to-face setting, the atmosphere would have been chaotic because of the assertion, emphasis, or persuasive contributions of the architects and structural engineers. However, the results in Tables 1 and 2, Scale 1 provide factors representing the interests of participants from the different professions, and the value of the factors was improved and realigned in Table 2, due to the objective evaluation by participants. This progression sustained the interest of the professionals in the exercise and the result, shown in Table 3, was mutually accepted.

It is interesting to note that aesthetics and stability are influenced by the quality of materials, the skills of the operatives during the construction phase, the adoption of correct construction principles and practices, as well as the commitment to dedicated maintenance (Jadiadoleslami, et al., 2016). The first five factors, Table 3, Scale 1 are buildability, functionality, materials, cost, and maintenance. The actors that play the leading role in buildability are the contractors, while facilities managers take care of functionality and maintenance. This research highlights that, during the planning phase of any building project, these two essential professionals should, therefore, be involved as early as possible

(Meng, 2013; Antosson, et al., 2022). Furthermore, the fulcrum around which all the factors revolve is 'cost', the determinant of an excellent design, buildability, functionality during operation, and maintainability of the edifice. Similarly, in the current industry 4.0 scenario, Artificial Intelligence (AI) has emerged as a unique application of ICT features, making remarkable revolutions in manufacturing and production industries, empowering assembly lines in the manufacturing industry (Ghani, et al., 2022; Merhi and Harfouche, 2023), facilitating effective medical diagnoses and treatment of diseases (Hachoumi, et al., 2023), pioneering self-driving cars, automation of train transport systems and the development home appliances suitable for different use through the internet of things (IoT) (Khan, et al., 2023). In the same sense, AI has found its way to influence operations in public services (Alshebhi, et al., 2022), business management, consumer services and other multi-disciplinary services (Gursoy et al., 2019; Barstrom, et al., 2021). However, the inherently complex, high cost of ICT infrastructure and time-constrained operations have constituted limitations on how conservative industries adopts AI application in their operations (Abioye, et al., 2021). Other constraints limiting the adoption of AI includes the fact that AI is data-driven, requires long-term planning, resources, and effort to implement, as well as the training and retraining of employees. The integration of AI technologies into the different industrial sector is increasing because of the growing challenges, such as energy efficiency, environmental impact, and market competitiveness (Khan, et al., 2023). Adopting innovative AI solutions, is helping industries to overcome operational inefficiencies, automate routine tasks, and enhance decision-making processes.

Despite the potential advantages of AI in enhancing productivity, quality, safety, and operations management, certain industrial sectors are still reluctant to adopt it. One of such conservative industries is the construction industry, which may not be able to relate with these benefits of AI easily, due to the peculiarity of the operations of the industry; volatility due to fluctuating economic environment, lack of continuity of governance that negatively impact on its progress, resulting in low patronage and delayed payment for work done, which exert constraints in cash flow (Abioye, et al., 2021). It is worthy to note that a construction project of any infrastructure type is executed at considerable distances away from the company's head office, either in urban, semi-urban, rural or areas without regular human inhabitants. A typical infrastructure project is expected to contribute to the socio-economic well-being of the proximate communities, through direct and indirect employments. If AI is adopted, this may reduce the quantity of human capacities engaged for the project. Conversely, ICT infrastructure to support AI requires large upfront investment in the equipment, machinery, and technical expertise. These and many other constraints inhibit the introduction and application of AI in construction (Abioye, et al., 2021). Therefore, introducing AI into the construction and other conservative industries requires the contextual application of the principles used in finding solutions to typical GDM problems (Hall, et al., 2016; Perez, et al., 2018). Consequently, organizations must carefully evaluate the potential benefits and challenges associated with AI adoption to ensure a strategic approach that maximizes both short-term gains and long-term sustainability, considering the potential impact on organizational culture, workforce, and overall operational dynamics (Khan, et al., 2023). In this regard, decision on the choice and use of AI, especially in the conservative industries, should be approached carefully, allowing all stakeholders to buy into the concept progressively, through using suitable measuring tools for consensus building, like the Delphi technique and the linear integer Linkert scale as opposed to the mirror image (Allen and Saman, 2007; Kristowski, et al., 2015).

6. Conclusion and recommendations

The focus of this research was to investigate the impacts of the scale of measurement on the research results in CRPs for addressing a GDM problem and possible adaptation in resolving the introduction of AI in conservative industries. Two variants of the Likert scale 1-5 were evaluated, known as Scales 1 and 2, respectively. Both scales used a moderate benchmark. The results from Scale 1, gradually and progressively reduced the twenty-one factors (subject of the research), to thirteen and twelve, respectively, in two successive iterations. The quality value and hierarchy of the final twelve factors were refined in the second round of data collection and analysis, capturing the objective evaluation of participants. The results put some latent factors under the spotlight, buildability, functionality, materials, cost, and maintenance. At the same time, it placed conformity to code, stability, and aesthetics at a moderate level and the less talked about factors of environmental friendliness, sustainability, site condition, and experience were given due recognition. This broad-based solution aptly captured the interest of all the built environment professionals who participated in the research exercise, without any coercion. Similarly, due to the high capital investments into AI, in terms of infrastructure and human capacity, coupled with the volatility of some industries, especially the conservative ones, the introduction of AI should adopt the principles of solving a generic GDM problems.

The second measuring scale, the mirror image of the Likert scale 1-5, produced sharp and functional results, reducing the twenty-one factors to nine and eight, respectively. This approach is useful for streamlining many options into a

few, to guide immediate and effective decision-making in GDM problems, such as developing a white paper from a committee report for immediate action. Otherwise, in the generic GDM scenario, the sharp reduction of the factors would infringe on the interests of some of the participants who may be discouraged from further participation in the exercise.
Therefore, this research recommends that the choice of measuring scale should be influenced by the research objectives.

References

Abioye, S. O, Oyedele, L. O, Akanbi, L, Ajayi, A, Delgado, J. M. D, Bilal, M, Akinade, O. O, Ahmed, A., Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges. *Journal of Building Engineering*, vol. 44, 2021, https://doi.org/10.1016/j.jobe.2021.103299

Allen, E. I and Seaman, C. A., Likert scales and data analyses-statistical roundtable, *Quality Progress* pp. 64–65, 2007. Available at: www.asq.org .

Alshehhi, K, Cheaitou A and Rashid, H., Adoption Frameworks for Artificial Intelligence in the Public Sector: A Systematic Review of Literature, *Proceedings of the 3rd South American International Industrial Engineering and Operations Management Conference*, pp. 919-929, 2022, Asuncion, Paraguay.

Antosson, F, Lagerkvist, J, Lindvall, D and Rempling, R., Optimal time for contractors to enter infrastructure projects, *Procidia Computer Science,* vol. 196, pp. 990–998. 2022

Baka, A, Figgou, L, and Triga, V., Neither agree, nor disagree': A critical analysis of the middle answer category in voting advice applications, *International Journal of Electronic Governance,* vol. 5, no. ¾, pp. 244–263, 2012.

Brady, S. R, Utilizing and adapting the Delphi method for use in qualitative research, *International Journal of Qualitative,* vol. 14, no. 5, pp. 1–6, 2015.

Breen, R. L, A practical guide to focus-group research, *Journal of Geography in Higher Education,* vol. 30, no. 3, pp. 463–475, 2006.

Brown, S., Using focus groups in naturally occurring settings, *Quality Research Journal,* vol. 15, no. 1, pp. 86–97, 2015.

Burström, T, Parida, V, Lahti, T, Wincent, J., AI-enabled business-model innovation and transformation in industrial ecosystems: A framework, model and outline for further research, *Journal of Business Research,* vol. 127, pp85-95, 2021.

Chimi, C. J and Russell, D. L, The Likert scale: A proposal for improvement using quasi-continuous variables, *Proc. ISECON,* vol. 26, no. 3, pp. 1–10, 2009.

Cullerton, K, Adams, J, Francis, O, Forouhi, N and White, M, Building consensus on interactions between population health researchers and the food industry: Two-stage, online, international Delphi study and stakeholder survey, *PLoS ONE*, vol. 14, no. 8, pp. 1–17, 2019.

Dilks, D. D, Julian, J. B, Kubilius, J, Spelke, E and Kanwisher, N, Mirror-image sensitivity and invariance in object and scene processing pathways, *The Journal of Neuroscience* vol. 31, no. 31, pp. 11305–11312, 2011.

Donohoe, H. M and Needham, R. D, Moving best practice forward: Delphi characteristics, advantages, potential problems, and solutions, *International Journal of Tourism Research* vol. 11, pp. 415–437, 2009.

Dumay, J and Cai, L., Using content analysis as a research methodology for investigating intellectual capital disclosure: A critique, *Journal of Intellectual Capital* vol. 16, no. 1, pp. 121–155, 2015.

Fink-Hafner, D, Dagen, T, Douˇsak, M, Hafner-Fink, M and Novak, M., Delphi method: strengths and weaknesses, *Metodoloˇski zvezki*, vol. 16, no. 2, pp. 1–19, 2019.

Fletcher, A. J and Marchildon, G. P, Using the Delphi method for qualitative, participatory action research in health leadership, *International Journal of Qualitative Methods* vol. 13, pp. 1–18, 2014.

French-Bravo, M and Crow, G., Shared governance: The role of buy-in in bringing about change, *The Online Journal of Issues in Nursing,* vol. 20, no. 2, pp. 2–11, 2015.

Ghani, E. K Ariffin N and Sukmadilaga, C., Factors influencing artificial intelligence adoption in publicly listed manufacturing companies: A technology, organisation, and environment approach*, International Journal of Applied Economics, Finance and Accounting*, vol. 14, No. 2, pp. 108-117. 2022.

Gursoy, D, Chia, O. H, Luc L and Nunkoo, R., Consumers acceptance of artificially intelligent (AI) device use in service delivery, *International Journal of Information Management, vol.* 49, pp. 157-169, 2019.

Hachoumi, N, Eddabbah M and El Adib, A. R., Health sciences lifelong learning and professional development in the era of artificial intelligence, *International Journal of Medical Informatics,* vol. 178, pp. 1-7, 2023.

Hall, D. M, Anderson, M. B, Gilbertz, S. J and Ward, L. C., Beyond "buy-in": designing citizen participation in water planning as research," *Journal of Cleaner Production* vol. 133, pp. 725–734, 2016.

Hallowell, M. R and Gambatese, J. A, Qualitative research: Application of the Delphi method to CEM research, *Journal of Construction Engineering and Management* vol. 136, pp. 1–9, 2010.
Hasson, F and Keeney, S, Enhancing rigour in the Delphi technique research, *Technological Forecasting & Social Change* vol. 78, pp. 1695–1704, 2011.
Helms, C, Gardner, A and McInnes, E, The use of advanced web-based survey design in Delphi research, *Journal of Advanced Nursing,* vol. 73, no. 12, pp. 3168–3177, 2017.
Jadidoleslami, S, Saghatforoush, E, Ghaleenoe, N. K and Preece, C., Benefits of using constructability, operability, and maintainability in infrastructure projects: A meta-synthesis, *Proceedings of the 21st International Symposium on Advancement of Construction Management and Real Estate* 347–363, 2016, Hong Kong, Available at: https://link.springer.com/chapter/10.1007/978-981-10-6190-5_31
Khan, A. N, Mehmood, J. K, Soomro M. A and Bresciani, S., Paving the way for technological innovation through adoption of artificial intelligence in conservative industries, *Journal of Business Research*, vol. 165, October 2023, https://doi.org/10.1016/j.jbusres.2023.114019
Kistowski, J. V, Arnold, J. A, Huppler, K, Henning, J. L, Lange, K. D and Cao, P., How to build a benchmark, in *ICPE '15: Proceedings of the 6th ACM/SPEC International Conference on Performance Engineering,* January 2015, pp. 333–336. Available at: https://doi.org/10.1145/2668930.2688819 .
Kulas, J. T, Stachowski, A. A. and Haynes, B. A, Middle Response Functioning in Likert-responses to Personality Items, *Journal of Business Psychology,* vol. 22, pp. 251–259, 2008.
Kwong, C, Chen, Y, Choy, K and Ye, Y, A novel fuzzy group decision-making approach to prioritising engineering characteristics in QFD under uncertainties, *Internal Journal of Production Research,* vol. 49, no. 19, pp. 5801–5820, 2011.
Labella, A, Liu, Y, Rodríguez, R. M and Martínez, L, Analysing the performance of classical consensus models in large-scale group decision making: A comparative study, *Applied Soft Computing,* vol. 67, pp. 677–690, 2018.
Levino, N. A and Morals, D. C, Participatory multicriteria decision making model in Hydrographic Basin Committee, in *2012 IEEE International Conference on Systems, Man, and Cybernetics (SMC),* Seoul, Korea, 14–17 October 2012. **https://doi.org/10.1109/ICSMC.2012.6377792**.
Li, G, Kou, G and Peng, Y, A group decision-making model for integrating heterogeneous information, *IEEE Transactions on Systems, Man, and Cybernetics: Systems* vol. 48, no. 6, pp. 982–992, 2018.
Meng, X., Involvement of facilities management specialists in building design: United Kingdom experience, *ASCE Journal of Performance of Constructed Facilities,* vol. 27, no. 5, pp. 500–507, 2013.
Merhi M. I and Harfouche A., Enablers of artificial intelligence adoption and implementation in production systems, *International Journal of Production Research*, pp. 1-15, January 2023. https://doi.org/10.1080/00207543.2023.2167014
Meskell, P, Casey, D, Murphy, K and Shaw, D, Insights into the use and complexities of the Policy Delphi technique, *Nurse Researcher,* 21, no. 3, pp. 32–39, 2014
Morais, D. C and De Almeida, A. T, Group decision making on water resources based on analysis of individual rankings, *Omega,* vol. 40, no. 1, pp. 42–52, 2012.
Murray, A. L, Booth, T and Molenaar, D., When Middle Really Means “Top” or “Bottom”: An analysis of the 16PF5 using Bock's nominal response model, *Journal of Personality Assessment,* vol. 98, no. 3, pp. 319–331, 2016.
Ogbeifun, E, Zwalda, N, Imil, I A and Pretorius, J H C, Harmonising aesthetics, functionality, stability, buildability, serviceability, maintainability and cost in infrastructure development, in *Proceedings of the 46th Australasian Universities Building Education Association (AUBEA) 2023 Conference*, Auckland, New Zealand, November 26–28, 2023.
Ogbeifun, E and Pretorius J H C, (2023), Aesthetics an overrated factor in building design, Proceedings of the *4th International Conference on Maintenance and Intelligent Asset Management (ICMIAM2023)*, December 6-8, Victoria, Australia.
Ogbeifun, E, Mbohwa, C and Pretorius, J. H. C., Achieving consensus devoid of complicity: Adopting the Delphi technique, *International Journal of Productivity and Performance Management*, vol. 66, no. 6, pp. 1–16, 2017.
Ogbeifun, E, Mbohwa, C and Pretorius, J. H. C, Complementing a Delphi exercise with a focus group session, in *Proceedings of the 2016 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, Bali, Indonesia Dec. 4-7, 2016, pp. 1269–1273. https://doi.org/10.1109/IEEM.2016.7798063 .
Ogden, J, and Lo, J., How meaningful are data from Likert scales? An evaluation of how ratings are made and the role of the response shift in the socially disadvantaged, *International Journal of Health Psychology,* vol. 12, pp. 350–361, 2012.

Palomares, I, Herrera, F and Martínez, L, A consensus model to detect and manage noncooperative behaviors in large-scale group decision making, *IEEE Transaction Fuzzy System* vol. 22, no. 3, pp. 516–530, 2014.

Pasipatorwa, P, Ogbeifun, E and Pretorius, J. H. C., Improving on machine reliability and productivity through data analysis, in *Proceedings of the 4th African International Conference on Industrial Engineering and Operations Management*, Nsuka, Nigeria, 5–7 April 2022. Available at: https://ieomsociety.org/proceedings/2022nigeria/48.pdf.

Perez, I J, Alonso, S, Cabrerizo, F. J, Chiclana, F, Dong, Y. C and Herrera-Viedma, E, On dynamic consensus processes in group decision making problems, *Information Sciences,* vol. 459, pp. 20–35, 2018.

Pimentel, J. L, A note on the usage of Likert scaling for research data analysis, *University of Southern Mindanao Research & Development*, vol. 18, no. 2, pp. 109-112, 2010.

Piotrowski, A. P, Napiorkowski, J. J and Piotrowska, A. E., Choice of benchmark optimization problems does matter, *Swarm and Evolutionary Computation,* 83, December 2023, [in press]. Available at: https://doi.org/10.1016/j.swevo.2023.101378 .

Robertson, F, Barrow, J, Bishop, C, Katitjin, K, Nannup, A, Nannup, N and Wajrak, M., Participatory action and dual-lens research, *Qualitative Research Journal,* vol. 17, no. 4, pp. 283–293, 2017.

Rodríguez, R. M, Labella, A, De Tre, G and Martínez, L, A large scale consensus reaching process managing group hesitation, *Knowledge-Based System,* vol. 159, pp. 86–97, 2018.

Rusinowska, A, Eklund, P and De Swart, H, Consensus reaching in committees, *European Journal of Operational Research,* vol. 178, no. 1, pp. 185–193, 2007.

Walser, R. S, Maier, R and Seeber I, The fewer, the better? Effects of decomposition of information load on the decision-making process and outcome in idea selection, in *Proceedings of the 27th European Conference on Information Systems (ECIS)*, pp. 8–14 June 2019, Stockholm & Uppsala, Sweden, Available at: https://aisel.aisnet.org/ecis2019_rp/180 (Accessed: 7 October 2023).

Wilson, V., Research methods: Content analysis," *Evidence Based Library and Information Practice,* vol. 11, no. 1, pp. 41–43, 2016.

Zhang, H, Chiclana, F, Dong, Y and Yu, S, Consensus efficiency in group decision making: A comprehensive comparative study and its optimal design, *European Journal of Operational Research,* vol. 275, no. 2, pp. 580–598, 2019.

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