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EXPLORING PERCEPTUAL MAPPING TECHNIQUE AS AN INNOVATIVE METHOD OF REPRESENTING CONSTRUCTION COST INFORMATION

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ABSTRACT

Effective representation of cost information is crucial for decision-making. While traditional methods like Bills of Quantities provide essential details, their format can pose challenges for swift interpretation and comparison. This study explores perceptual mapping as an innovative complementary tool to enhance the representation of construction cost information. Adopting a qualitative methodology, data were gathered via semi-structured interviews with 16 experienced professionals comprising clients, Architects, Quantity Surveyors, Engineers in the Sri Lankan construction industry. Thematic analysis identified key insights into the applicability and benefits of perceptual mapping. The findings indicate that perceptual maps, when used in conjunction with detailed reports, significantly enhance cost data visualisation, facilitating quicker comparisons and improving decision-making efficiency. Participants recognised their value in overcoming the usability limitations of conventional formats. The study concludes that perceptual maps offer a powerful enhancement to traditional documentation by providing a clear comparative overview. This provides a clear comparative overview with notable implications for practical decision support and the theoretical understanding of information visualisation in the sector, especially when integrated with traditional documentation.

Keywords: *Construction; Cost Visualisation; Decision Support; Perceptual Mapping; Stakeholder Communication.*

1. INTRODUCTION

The construction industry is unique and complex and involves diverse stakeholders with varied project interests (Ebekozien et al., 2024). Stakeholder engagement depends heavily on the information produced and the value of their inputs during project execution. Among these, cost information is crucial for cost optimisation and effective decision-making (Safaa Eldin et al., 2024). Robson et al. (2016) emphasized the importance of cost information in addressing parties' concerns in construction. Thus, representing cost

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information understandably to various stakeholders is a vital aspect of construction projects.

The impact of cost information differs among parties; for instance, a contractor's unforeseen profit might be a client's loss. Each party's understanding depends on their role-specific information requirements (Campbell, Viza & Arnaudova, 2023). This varied interpretation is linked to mental or cognitive representations (Schack & Frank, 2021). Individuals uniquely attend to, grasp, and interpret information (Moskowitz & Gill, 2013), necessitating more attention to how cost information is represented.

Even though the preliminary and pre-tender estimates provide comprehensive cost information, the lengthy tabular presentation at times challenges swift comparison of different design options. Stakeholders, especially those without or with less technical training, find it challenging to understand the connections between design options and their impact on costs, time and performance (Love et al., 2013). This gap can slow down decision-making.

Perceptual mapping is a visual technique for comparing multi-dimensional attributes by displaying relative information from different individual standpoints (Gigauri, 2019). The technique works by having people rate items based on key attributes; these ratings are then plotted graphically to create a map that visually represents the items' perceived relationships (Gower et al., 2010). This visual representation of objects, often termed multi-dimensional scaling, aids decision-making with finer detailing and is commonly used in marketing for brand positioning (Chipoco, 2016; Gigauri, 2019). Similarly, perceptual maps in construction projects could be used for decision making based on different attributes and variables. Hence, this technique could also appropriately represent construction cost information in varied perceptions with minor detailing for successful project delivery.

Construction cost information is crucial for estimating, planning, designing, and forecasting (Rodrigues et al., 2022). Bills of Quantities (BOQ) are the most common representation, offering a general idea about construction costs, analysis, comparison, estimation, supporting bank loans, progress measurement, and tendering (Abdullahi et al., 2021). However, newer software tools for cost information incorporate Building Information Modelling (BIM). BIM represents the current industry benchmark for digital cost integration. It provides the context for many innovative approaches. BIM digitally represents a building, integrating all information types and facilitating multi-party collaboration. Discussions on 5D BIM (cost dimension) are widespread, with research extending to blockchain and digital twin technologies (Apinayan et al., 2023). This highlights the need to focus on innovative cost information representation for stakeholder benefits. Perceptual mapping is one such technique, offering multi-dimensional perceptual information on project costs relative to key comparison factors.

This study, therefore, aims to explore perceptual mapping as an effective tool to enhance traditional methods of cost information representation. The objectives are:

1. Identify the challenges stakeholders face when making swift, multi-attribute comparisons in existing cost representation methods
2. Examine the applicability of perceptual mapping technique to represent cost information
3. Analyse the benefits of integrating perceptual mapping in current documentation and technological trends.

2. LITERATURE REVIEW

This section reviews the literature on cost information representation, its issues, and the applicability of the perceptual mapping technique to construction.

2.1 EXISTING COST INFORMATION REPRESENTATION TECHNIQUES

2.1.1 Construction Cost Information

Construction is inherently uncertain, primarily due to time, cost, and quality interdependencies (Ekung et al., 2021). The cost factor is crucial for project success, particularly in addressing uncertainties (Adedokun et al., 2019). Understanding and managing cost information enhances project delivery effectiveness and predictability. Construction involves numerous parties whose roles, expectations, and contributions underscore the importance of cost information (Wang & Qiao, 2024). Cost information requirements vary in type and format throughout the project lifecycle, depending on the context and decision-making needs. Consequently, the industry has employed various representation methods for effective cost management (Gómez-Cabrera et al., 2023).

2.1.2 Cost Information Representation Methods

Historically, BOQs have been the most common cost representation method (Razali et al., 2016), evolving into a standardised tabular format. Construction parties have adapted to BOQs, with standardisation playing a role (Luyue et al., 2022). Razali et al. (2016) noted a consistent format for all parties, with information extracted for specific purposes. However, issues exist in accessing, understanding, and interpreting cost information from different perspectives, suggesting that BOQs are only one option among other potentially effective methods (Zheng et al., 2023).

Multiple cost information requirements arise at different project stages. Cost planning determines project budgets through pre-contract estimates, with BOQs as detailed outputs in later stages (Ebekozien & Aigbavboa, 2024). Other formats include bar graphs, S-curves, cost-to-complete reports, and feasibility studies, often presenting static information from a single viewpoint. BIM offers multi-dimensional modelling, incorporating cost alongside other dimensions (Sepasgozar et al., 2022). Innovative technologies such as dashboards (Gara et al., 2021), Augmented Reality (AR) (Senanayake et al., 2023), and Virtual Reality (VR) (Lee et al., 2022) are expanding communication possibilities. Thus, cost information is represented in multiple ways: tables, texts, graphs, and dashboards.

2.1.3 Innovative Representation Methods

"A mental representation is a system of symbols isomorphic to some aspect of the environment, used to make behaviour-generating decisions that anticipate events and relations in that environment" (Gallistel, 2001, p. 1). Different individuals visualise information from varied perspectives (Hebart et al., 2020). For instance, "car" evokes diverse images (Ferrari, red car, roofless car) based on an individual's history, education, experience, and other influencing factors (Luyue et al., 2022). As a psychological process, a better understanding of mental representation offers clearer perspectives (Luyue et al., 2022), connecting thinking with concept usage (Hebart et al., 2020). This underscores the need for diverse cost information representation methods to cater to the interests of different construction parties.

2.2 PERCEPTUAL MAPPING TECHNIQUE AS A COST INFORMATION REPRESENTATION METHOD

2.2.1 Perceptual Mapping Technique

Perceptual mapping, popular in marketing, compares multi-dimensional attributes from different perceptions (Gigauri, 2019). It aids comparative analysis, maps benefits, complex relationships, and the relative positioning of information (Gigauri, 2019). Applications include brand positioning, product benefit mapping, and comparative decision-making for grouping options. Najafizadeh (2012) noted its utility in displaying options relative to individual perceptions, typically using two dimensions but extendable to more. Mapping involves rating against predetermined attributes and plotting these values graphically. Figure 2 shows a multi-dimensional scaling map of beer brands based on attributes like "Heavy," "Light," and characteristics like "Popular with men". This visual placement aids selection based on varied criteria. Similarly, perceptual maps can support construction-based, cost-focused decision-making.

Figure 1 illustrates a perceptual map comparing different ceiling materials based on "Cost" and "Durability". The Timber ceiling is shown as "High Cost" and "High Durability," while the Gypsum Frame ceiling is "Low Cost" and "High Durability". The degree of durability is indicated by the dot's proximity to the attribute; thus, timber is more durable than gypsum. This exemplifies how perceptual maps can facilitate decision-making.

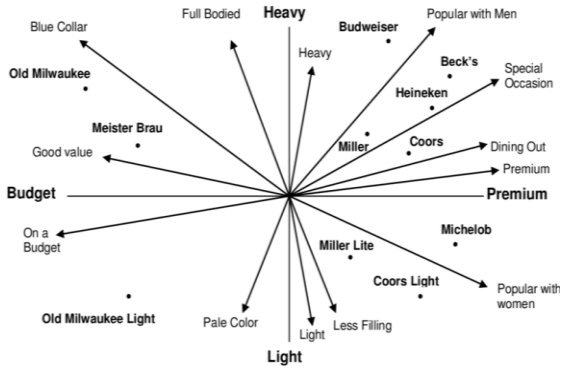


Figure 1: Perceptual Map Example 1
Source: (Cornelius et al., 2010)

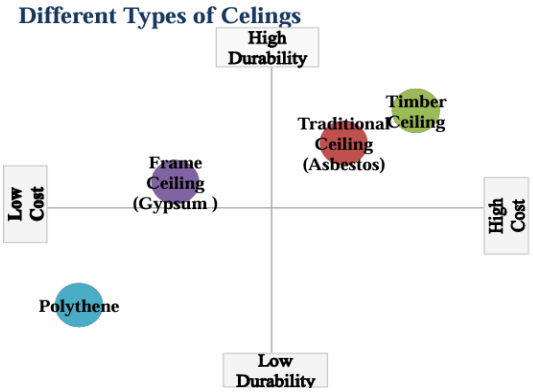


Figure 2: Perceptual Map Example 2

2.2.2 Utilizing Perceptual Maps

Perceptual maps are powerful analytical tools for comparing alternatives against defined characteristics, as seen in the ceiling type example (Figure 1). They eliminate the need to go through individual data elements for each alternative by presenting all options and their significant attributes in one diagram. Psychologically, perceptual mapping graphically interprets the mental representation of an item in the human mind. Communication to non-technical users is more comfortable with shorter reaction times, as observed in marketing.

3. RESEARCH METHODOLOGY

The research approach is interpretivism, focusing on human experiences and phenomena (William, 2024). Cost information and opinions on its representation are subjective,

warranting a qualitative methodology to interpret and generalise emergent patterns from individual experiences.

The research process began with a literature review on cost information representation and perceptual mapping. Data collection used semi-structured interviews with experts, suitable for extracting relevant information aligned with the research objectives (Saunders et al., 2019). Qualitative saturation typically occurs between nine and seventeen interviews (Hennink & Kaiser, 2022). Twenty professionals were selected via purposive sampling based on their experience, profession, designation, and experience with cost information in multiple contexts. All selected professionals were practicing in the Sri Lankan construction sector, where Bills of Quantities are standard and the norm for cost management. Accordingly, all interviewees possessed a high degree of familiarity with BOQs. Sixteen interviews were conducted, confirming data saturation. Interviews followed a guideline with spontaneous questions to maintain objective alignment. A perceptual map developed from a conventional report on partition wall material costs was tested with the interviewees. Table 1 presents the profiles of the interviewees.

Table 1: Profile of Interviewees

Professional category	Respondent No.	Area of expertise	Experience (Years)
Client	C01	Developer	18
	C02	Developer	15
	C03	Developer	12
	C04	Developer	18
Architect	A01	Senior Architect	31
	A02	Architect	12
	A03	Senior Architect	32
	A04	Senior Architect	22
Quantity Surveyor	QS01	Senior Quantity Surveyor	15
	QS02	Senior Quantity Surveyor	24
	QS03	Senior Quantity Surveyor	18
	QS04	Senior Quantity Surveyor	16
Engineer	E01	Senior Engineer	15
	E02	Senior Engineer	11
	E03	Project Manager	16
	E04	Senior Engineer	21

Manual thematic analysis was employed, focusing on identifying, analysing, and interpreting patterns of meaning ('themes') within the qualitative data relevant to research objectives (Humble & Mozelius, 2022). Interview transcripts were coded, and similar theme-based ideas were grouped and analysed from Client, Engineer, Architect, and Quantity Surveyor perspectives. Findings from the literature and data analysis were then discussed to achieve the research aim and objectives.

4. RESEARCH FINDINGS AND DISCUSSION

This section analyses findings categorised by major stakeholder groups: client, architect, engineer, and quantity surveyor. The developed perceptual map (Figure 3), tested with interviewees, formed the basis for discussion on their perceptions. The findings are discussed along with the literature outcomes to achieve the research objectives.

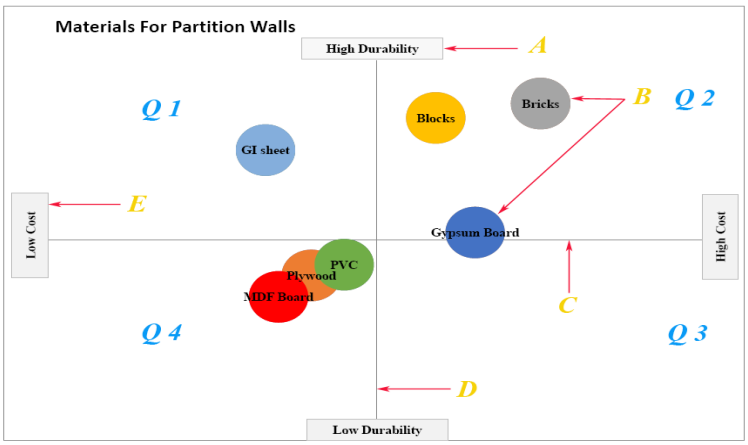
4.1 CLIENT'S POINT OF VIEW

C04 explained that perceptual maps "*can save time by depicting all the materials within one page,*" allowing anyone to "*compare two items by looking at its position in the Cartesian plain*". Perceptual maps display all items on one page, facilitating direct access for comparing several items by cost and other characteristics, simplifying selection, and saving time. C01 commented, "*when there is a new way like perceptual map, it could be used in important cost impacting decisions*", especially when clients imply changes or variations. This enhances decision-making efficiency.

C02 noted, "*Even if I find the required cost information...with current methods, I may need another method to compare those cost information with different characteristics*". Perceptual maps alleviate issues with existing methods that involve repetitive work, offering better communication, and enriched presentation. Sequential information access limits readability and understandability, causing time wastage and requiring further processing (comparison, filtering). C04 stated perceptual maps "*can show details of the compared items and the comparison process within one frame*," managing all information on one page and obviating further searches compared to reports.

4.2 ARCHITECT'S POINT OF VIEW

A02 expressed, "*By using a perceptual map I can get an idea of how these alternatives vary according to its cost and the other specific attribute*". Architects deal with many alternatives when designing, needing to assess each characteristic and cost to find the best fit. A01 found this technique "*perfect*" for such scenarios. Since all alternatives are visible on one page for comparison by cost against an attribute, selecting the best option(s) becomes easier. Users can also group alternatives before consulting a detailed report.



A = Variable Characteristic
B = Element
C = Constant Axis
D = Variable Axis
E = Constant Characteristic (Cost)
Q1 = [Low Cost, High Y] Quadrant
Q2 = [High Cost, High Y] Quadrant
Q3 = [High Cost, Low Y] Quadrant
Q4 = [Low Cost, Low Y] Quadrant

Figure 1: Developed perceptual map technique

A03 stated, "*if there is a report only, I have to go through all the pages... So, it will be time consuming. But if we have mechanism to select the areas need to be go through... it will be more efficient. In case of perceptual maps, it looks promising*". Perceptual maps use quadrants based on attributes, dividing alternatives accordingly. Users can select materials from the relevant quadrants and refer only to those in the report. A04 clarified, "*By using Perceptual Map we can eliminate materials which we don't need... if I search item with related to cost and durability; I might go for [low cost, high durability] quadrant... It will depend on user to user. But still using Perceptual Map will help to reduce the scope of selection... Then after I can get details of selected items using report*". This shows that the technique can sort/group alternatives, allowing users to analyse a selected group further with the report. A04 suggested combining both techniques for better cost information representation.

4.3 ENGINEER'S POINT OF VIEW

E04 stated, "*This technique shows the distribution of materials based on cost and other selected characteristics. We can group materials quadrant wise and can select... materials in the quadrant which suit our idea*," showing an opinion similar to C04 and A04. E04 labelled map quadrants by usefulness for material selection (see Figure 4).

According to E04, the Engineering quadrant (Low Cost, High Y) offers the best selection due to low cost and high characteristic value. The Research and Development quadrant (High Cost, High Y) materials are for research and user-dependent. Primitive quadrant (Low Cost, Low Y) materials suit temporary works, while Non-Engineering quadrant (High Cost, Low Y) materials should be discouraged. E03 added, "*As Engineers we are looking at engineering quadrant when undertaking a sustainable project execution... to*

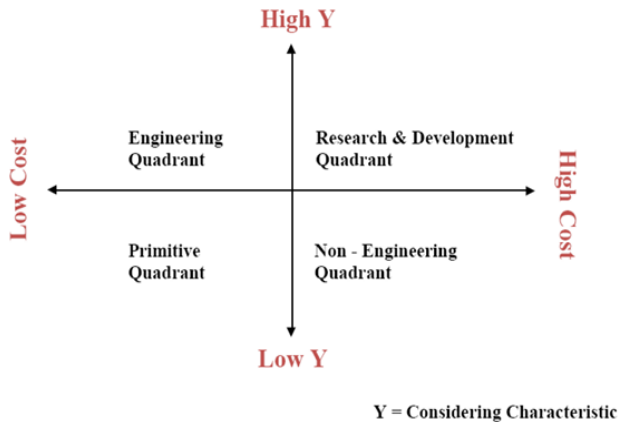


Figure 2: Diagram to depict comments of E04 interviewee

select materials in engineering quadrant, because we have the idea of saving material cost, reducing wastage and improve other related characteristics such as quality, durability etc.". Perceptual maps, with their quadrant division, allow engineers to easily identify materials in the engineering quadrant.

E04 noted that a report's efficiency is dependent and not inherently inefficient. E04 added, "*We can use Perceptual Map to sort the materials... and then can refer to the report to see further details*", aligning with A04's idea of using both techniques.

4.4 QUANTITY SURVEYORS' POINT OF VIEW

QS01 stated, "*This technique provides easy comparison between alternatives. QS can give advice the Client about characteristics of alternative material compared to Clients' money... by using this method*". Projects have estimated budgets, and this technique can depict the best alternative for that budget. QS02 suggested, "*I can use perceptual map to select few alternatives and if I cannot get best alternative... I can refer to other ways. So, I think first we must go through perceptual map and the other detailed information could be interlinked...*". Users can refer to reports if selected materials from the map conflict, an idea also shared by A04 and E04.

QS04 mentioned, "*I think we can't one hundred percent rely on the perceptual map... it is a summarised version of a cost report. To make sure reliability of any decision... we need the report... Even if the report cannot be accessed easily, the perceptual map can be accessed easily*". Both methods have limitations, but their combination can reduce these. Perceptual maps offer direct access, while reports provide more information, leading to effective and efficient results.

4.5 DISCUSSION OF FINDINGS

A common theme from interviews is the advantage of perceptual maps in enabling quick comparisons and decision-making with multiple alternatives. Table 2 presents the characteristics of perceptual maps versus conventional reports, as identified by stakeholders.

Table 2: Identified characteristics of perceptual map

Professional category	Conventional report	Perceptual map
Client	Time consuming	Time saving
	Cannot use for grouping or sorting	Can use for grouping or sorting
	Sequential access	Direct access
	Less speed of grabbing data	High speed of grabbing data
	Slow decision-making process	Quick decision-making process
	Alternative element comparison is difficult	Alternative element comparison is easy
Architect	More informative	Less informative
	Cannot use for grouping or sorting	Can use for grouping or sorting
	Alternative element comparison is difficult	Alternative element comparison is easy
Engineer	Cannot super imposed with multiple Perceptual maps	Can super imposed with multiple Perceptual maps
	Element filtering cannot be done	Element filtering can be done
	Cannot use for grouping or sorting	Can use for grouping or sorting
Quantity Surveyor	Difficult to understand	Easy to understand
	More informative	Less informative
	Descriptive format	Graphical format

The findings confirm that existing methods can lack clarity and require further processing, an issue that perceptual maps can minimise for all considered stakeholders. The interviewees identified several scenarios for using perceptual maps in projects (refer to Table 3).

Table 3: Possible scenarios of using perceptual map technique

Professional Category	Scenario
Client	Compare the cost of alternative materials against specific attribute
Architect	Compare the cost of alternative elements against specific attributes (including both materials and services)
	Group elements according to users' idea
Engineer	Grouping or Sorting elements under given criteria
Quantity Surveyor	Compare the cost of alternative elements with specific attributes (including both materials and services)

Quantity Surveyors and Architects, particularly, suggested that perceptual maps are most powerful alongside, not replacing, detailed cost reports like BOQs. The map offers a comparative overview, while the report provides detailed verification, creating a synergetic effect. This addresses the limitations of relying solely on a summarised view, aligning with the literature on mental representation: while visual tools aid perception, stakeholders need varying detail levels based on role and context. The engineer's quadrant-based analysis highlights the capacity of perceptual maps for the efficient presentation of complex information distribution.

4.6 DEVELOPMENT SUGGESTIONS

Professionals suggested development options for perceptual maps based on their perceptions of characteristics and limitations during testing.

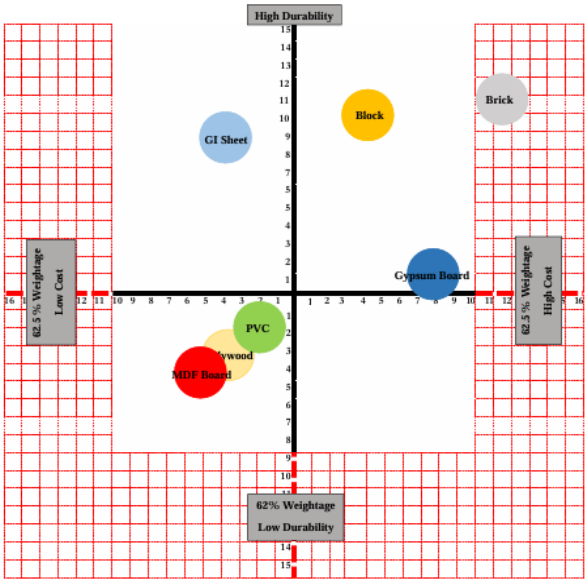


Figure 5: Developments B and C

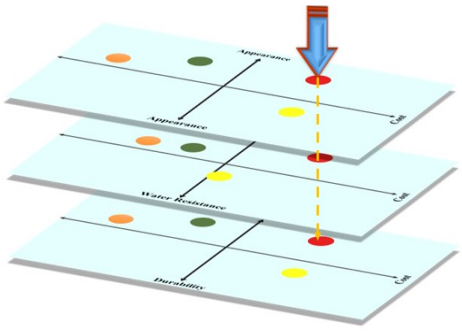


Figure 6: Super imposed perceptual map technique

1. Super-imposed method: Overlaying several perceptual maps created separately for different attributes for multi-attribute visualisation. (See Figure 5 for illustration).
2. Scaled axes: Scaling X and Y axes for quantified, accurate analysis when options within a quadrant need differentiation. (See Figure 6).
3. Weighted axes: Allowing weightages for attributes in decision-making to be applied to axes for direct visualised results. (See Figure 6).
4. Interactive linking: Linking map elements (circles) to the source report for more information, creating a dynamic cost presentation for better stakeholder decision-making.

5. CONCLUSIONS AND RECOMMENDATIONS

This study concludes that perceptual mapping is a valuable technique for enhancing the representation of construction cost information. The technique significantly improves the efficiency of comparing alternatives based on costs and other attributes, offering clearer visual communication for different stakeholders. The findings confirm that perceptual maps help overcome certain clarity and usability issues inherent in the existing formats of cost data representation. However, the research also highlights that perceptual mapping is most effective not as a standalone replacement, but as a complementary tool used alongside detailed cost reports, such as Bills of Quantities. This approach provides both a quick comparative overview and the necessary in-depth data for verification, thus ensuring robust decision support.

The implications of these findings extend to both theory and practice. Theoretically, this research contributes to understanding information visualisation and cognitive processing in complex professional domains, such as construction cost management. This demonstrates the successful adaptation of a marketing-originated tool to a new field, offering insights into how established techniques can be repurposed to address specific industry challenges. Furthermore, the emphasis on complementarity over replacement informs theories of technology integration, suggesting a nuanced path where new tools augment, rather than simply supersede, existing practices. For practitioners, the impact is tangible. Perceptual maps offer a more intuitive way to discuss and decide on cost-related matters, enhancing communication between diverse stakeholders such as Clients, Architects, Engineers, and Quantity Surveyors. This leads to more efficient decision-making, particularly when evaluating design or material alternatives. Quantity Surveyors, in particular, can leverage these maps to provide clearer, more impactful cost advice, thereby strengthening their advisory role.

To capitalise on these benefits and further address the challenge of effective cost information representation, it is recommended that Quantity Surveyors actively produce perceptual maps as a supplementary visualisation tool, especially for collaborative decision-making involving material or design alternatives. The ideal progression would be the integration of this capability into standard Quantity Surveying software, simplifying its generation and use. Exploring the synergy of perceptual maps with existing digital platforms, such as BIM environments, is also crucial for maximising data accessibility and utility.

As a qualitative study conducted with professionals in Sri Lanka, the findings of this study may have limited generalizability. Therefore, care should be taken when applying these

conclusions to different geographical or cultural setting where cost management practices may differ.

Looking ahead, further research should investigate the application of perceptual maps with a broader array of attributes beyond cost and durability. Assessing user experience across different project phases and among diverse stakeholder groups will also be vital to refine practical implementation and maximise the benefits of perceptual maps in the construction industry.

6. REFERENCES

Abdullahi, A. M., Mohamed, S. F., & Misnan, M. S. (2021). BIM-based bill of quantities: A novel approach for effective construction cost control. In *Proceedings international alumni convention* (pp. 31-38). UTMAlumni Universiti Teknologi Malaysia.

Adedokun, O. A., Aje, I. O., & Agboola, O. J. (2019). Investigation into the severity of factors predisposing construction projects to risks in Nigeria. *Journal of Building Performance*, *10*(1). 59-67. https://spaj.ukm.my/jsb/index.php/jbp/article/view/288

Apinayan, K., Perera, B. A. K. S., Weerasooriya, D., & Ranadewa, K. A. T. O. (2023). Leveraging BIM technology for improved accuracy in detailed cost estimation in Sri Lanka. *FARU Journal*, *10*(2), 1–10. https://doi.org/10.4038/faruj.v10i2.252

Campbell, A., Viza, E., & Arnaudova, R. (2023). Effective stakeholder engagement in the planning application process of new build major construction projects in Scotland, United Kingdom. *Journal of Advanced Management Science*, *11*(4), 130–138. https://doi.org/10.18178/joams.11.4.130-138

Chipoco, M. (2016). Perceptual Map teaching strategy. *Revista Digital de Investigación En Docencia Universitaria*, *10*(2), 83–91. https://doi.org/10.19083/ridu.10.447

Ebekozien, A., & Aigbavboa, C. (2024). *Principles of Basic Construction Economics in the 21st Century*. Emerald Publishing Limited. https://doi.org/10.1680/9781835498385

Ebekozien, A., Aigbavboa, C. O., & Ramotshela, M. (2024). A qualitative approach to investigate stakeholders' engagement in construction projects. *Benchmarking*, *31*(3), 866–883. https://doi.org/10.1108/BIJ-11-2021-0663

Ekung, S., Lashinde, A., & Adu, E. (2021). Critical risks to construction cost estimation. *Journal of Engineering, Project, and Production Management*, *11*(1), 19–29. https://doi.org/10.2478/jeppm-2021-0003

Fazeli, A., Dashti, M.S., Jalaei, F. and Khanzadi, M. (2021). An integrated BIM-based approach for cost estimation in construction projects. *Engineering, Construction and Architectural Management, 28*(9), 2828-2854. https://doi.org/10.1108/ECAM-01-2020-0027

Gara, J. A., Zakaria, R. B., Aminudin, E., Adzar, J. A., Yosif, O. S., & Yousif, O. S. (2021). The development of real-time integrated dashboard: An overview for road construction work progress monitoring. In *Journal of Hunan University (Natural Sciences), 48*(5), 127-137. https://jonuns.com/index.php/journal/article/view/590/587

Gigauri, I. (2019). Perceptual mapping as a marketing research tool for brand positioning. *International Journal of Economics and Management Studies*, *6*(4), 73–79. https://doi.org/10.14445/23939125/ijems-v6i4p110

Gómez-Cabrera, A., Gutierrez-Bucheli, L., & Muñoz, S. (2023). Causes of time and cost overruns in construction projects: A scoping review. *The International Journal of Construction Management*, *23*(13), 1107–1125. https://doi.org/10.1080/15623599.2023.2252288

Gower, J., Groenen, P., van de Velden, M., & Vines, K. (2010). *Perceptual maps: The good, the bad and the ugly* (ERS-2010-011-MKT). Erasmus Research Institute of Management. http://hdl.handle.net/1765/18462

Hebart, M. N., Zheng, C. Y., Pereira, F., & Baker, C. I. (2020). Revealing the multidimensional mental representations of natural objects underlying human similarity judgements. *Nature Human Behaviour*, *4*(11), 1173–1185. https://doi.org/10.1038/s41562-020-00951-3

Hennink, M., & Kaiser, B. N. (2022). Sample sizes for saturation in qualitative research: A systematic review of empirical tests. *Social Science and Medicine*, *292*, 100174. https://doi.org/10.1016/j.socscimed.2021.114523

Humble, N., & Mozelius, P. (2022). Content analysis or thematic analysis: Similarities, differences and applications in qualitative research. In *Proceedings of the 21st European Conference on Research Methodology for Business and Management Studies, ECRM 2022, 21*(1)*,* 76–81.

Lee, M., Chai, C., Xiong, Y., & Gui, H. (2022). Technology acceptance model for building information modelling based virtual reality (BIM-VR) in cost estimation. *Journal of Information Technology in Construction*, *27*, 914–925. https://doi.org/10.36680/j.itcon.2022.044

Love, P. E. D., Simpson, I., Hill, A., & Standing, C. (2013). From justification to evaluation: Building information modeling for asset owners. *Automation in Construction*, *35*, 208-216. https://doi.org/10.1016/j.autcon.2013.05.008

Luyue, H., Chang, L., Zhaojun, R., Xiuyan, Z., & Huiqin, Y. (2022). Research on project cost management under the mode of bill of quantities valuation. *International Journal of Frontiers in Engineering Technology*, *4*(2), 63-69. https://doi.org/10.25236/ijfet.2022.040210

Moskowitz, G. B., & Gill, M. J. (2013). *Person Perception*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780195376746.013.0058

Najafizadeh, N. S. (2012). A model for brand positioning of hygienic products using the most effective factors on competitive position and perceptual map technique. *African Journal of Business Management*, *6*(27), 8012-8112. https://doi.org/10.5897/ajbm11.2744

Gallistel, C.R. (2001). Mental representations, psychology of. In N.J. Smelser & P.B. Baltes (Eds.), *International Encyclopedia of the Social and Behavioral Sciences*. pp. 9691—9695. Elsevier. https://philpapers.org/rec/GALMRP

Razali, A., Tajudin, A., & Tajuddin, A. F. A. (2016). Importance and functions of bills of quantities in the construction industry: A content analysis. *International Journal of Engineering Science Invention*, *5*(3), 29–36. www.ijesi.org

Robson, A., Boyd, D., & Thurairajah, N. (2016). Studying 'cost as information' to account for construction improvements. *Construction Management and Economics*, *34*(6), 418–431. https://doi.org/10.1080/01446193.2016.1200734

Rodrigues, F., Alves, A. D., & Matos, R. (2022). Construction management supported by BIM and a business intelligence tool. *Energies*, *15*(9), 3412. https://doi.org/10.3390/en15093412

Safaa Eldin, A. M., Abdelalim, A., & Tantawy, M. (2024). Enhancing cost management in construction: The role of 5D building information modeling (BIM). *Engineering Research Journal*, *183*(3), 226–251. https://doi.org/10.21608/erj.2024.377303

Saunders, M. N. K., Lewis, P., & Thornhill, A. (2019). *Research methods for business students*. Pearson.

Schack, T., & Frank, C. (2021). Mental representation and the cognitive architecture of skilled action. *Review of Philosophy and Psychology*, *12*(3), 527–546. https://doi.org/10.1007/s13164-020-00485-7

Senanayake, S. M. A. H., Gunawardana, P. A. M., Perera, B. A. K. S., & Rajaratnam, D. (2023). Examining the potential use of augmented reality in construction cost management tools and techniques. *Journal of Engineering, Design and Technology*, *22* (6): 1847–1869. https://doi.org/10.1108/JEDT-10-2022-0512

Sepasgozar, S. M. E., Costin, A. M., Karimi, R., Shirowzhan, S., Abbasian, E., & Li, J. (2022). BIM and digital tools for state-of-the-art construction cost management. In *Buildings 12*(4), 396. https://doi.org/10.3390/buildings12040396

Wang, C., & Qiao, J. (2024). Construction project cost prediction method based on improved BiLSTM. *Applied Sciences*, 14(3), 978. https://doi.org/10.3390/app14030978

William, F. K. A. (2024). Interpretivism or constructivism: Navigating research paradigms in social science research. *International Journal of Research Publications*, *143*(1), 134-138. https://doi.org/10.47119/ijrp1001431220246122

Zheng, B., Hussain, M., Yang, Y., Chan, A. P. C., & Chi, H.-L. (2023). Trade-offs between accuracy and efficiency in BIM-LCA integration. *International journal of Engineering, Construction and Architectural Management*, 32(1), 237–258. https://doi.org/10.1108/ECAM-03-2023-0270