CONCEPT MAP TECHNIQUE TO REPRESENT THE BUILDING COST INFORMATION

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Abstract: Cost information is a crucial element in the construction industry; however, prevailing methods for presenting it to stakeholders are limited to formats such as Bills of Quantities (BOQs), quotations, and cost reports. This study, therefore examines the use of the Concept Map technique to represent cost information in construction, which is commonly used in other industries. Since this technique is not currently in practice in construction, the study employs a hypothetical scenario to demonstrate the comparative effectiveness of Concept Maps against traditional methods for cost information representation. A financial feasibility report was developed using the traditional method to represent cost information for a hypothetical construction project, alongside a Concept Map to visually explain the report's details. Subsequently, semi-structured interviews were conducted with industry experts to compare the effectiveness of the traditional report and the Concept Map for information representation. Content analysis was then performed to identify recurring opinions from experts regarding the use of the Concept Map technique for representing cost information. The study found that Concept Maps have key advantages over conventional reports, such as direct data access, data summarisation, graphical representation, and visible cost build-up. Further findings suggest that Concept Maps would be ideal for developing cost analyses, breakdowns, budgets, and for comparing cost information.

Keywords: *Concep Map, Cost Information, Representation, Construction Industry, 5D BIM*

1. Introduction

The construction industry is inherently complex due to the involvement of numerous parties, such as owners, contractors, consultants, the public, regulators etc.(Mgbeahuru & Olughu, 2022). The involvement of these parties depends heavily on the information obtained throughout the project lifecycle (Campbell et al., 2024). Among the various types of information used, cost information is particularly crucial (Robson et al., 2016). Cost information is a key factor that significantly influences the decisions and concerns of all parties involved in the construction industry (Robson et al., 2016). Consequently, comprehensibly representing essential building cost information to key stakeholders has become a significant challenge in the current context. Furthermore, precise understanding enables the effective use of cost information.

The effect of this cost information varies for each stakeholder involved in a project (Robson et al., 2016). This affects each party differently as the project progresses. For example, an unforeseen profit for the contractor could result in a loss for the client. The importance and usefulness of cost information depend on the extent to which the concerned stakeholder understands and interprets the relevant information (Campbell et al., 2024). According to Schack and Frank (2021), this is called the mental representation or cognitive representation of objects or data. Each individual is unique, and as such, their approach to receiving, processing, and interpreting information may differ significantly from one another (Moskowitz & Gill, 2013). According to Sharma et al. (2023), to effectively understand information, a person must have a foundational grasp of the concepts of the subject area. Without this basic knowledge, there is a risk of conflict between what is observed and what is ultimately understood (Bhuyan, 2023). A similar situation can arise when presenting cost information to interested parties who are not fully familiar with the building process. Misunderstanding cost information can lead to various problems throughout the project lifecycle.

Concept Map is a powerful teaching and learning technique (Wang, 2019). This technique was developed using Ausubel's cognitive theory on meaningful learning (Novak & Canas, 2007). According to guidance on meaningful learning techniques, an individual must relate new knowledge to relevant concepts that they already know (Novak & Canas, 2007). Ausubel further explains that a learner should be taught according to what they already know, rather than according to "age" or "stage" and this type of teaching will fall under meaningful learning (Bryce & Blown, 2023).

According to Anh et al. (2023), cost information plays a vital role in decision-making processes such as estimating, planning, designing, developing, and forecasting. In the Sri Lankan context, BoQ is the most frequently used cost information representation method in Sri Lanka for almost every stage of construction, such as to get a general idea about construction cost, cost analysis, cost comparison, cost estimation, to obtain bank loans and funds, to measure progress of construction

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works, and tendering purposes (Gunathilaka & Senevirathne, 2013; Randeniya et al., 2018). Additionally, a discussion is underway regarding the introduction of the 5D Building Information Modeling (BIM) approach in Sri Lanka for cost estimation, aiming to create a digital representation of cost information (Kanimaruthan et al., 2024). However, this initiative is still progressing toward becoming an established practice (Kanimaruthan et al., 2024). In addition to BoQ and 5D-BIM, there is no clear evidence of other cost representation methods being discussed or adopted in Sri Lanka. Thus, there is a distinct need for the Sri Lankan construction industry to adopt innovative methods for representing cost information that can be effectively utilised in various scenarios. Innovative methods for representing cost information can provide a clear visualisation of the situation for different stakeholders in the construction industry. Additionally, these methods provide a comprehensive view of cost information and help minimise misunderstandings among stakeholders. Concept Map technique is an innovative method used in many other fields, such as education, biology, history, mathematics, engineering, computer science, and communication, to represent information effectively (Freeman & Urbaczewski, 2001; Malekzadeh et al., 2020). Therefore, this study aims to explore the potential of using the Concept Map technique to represent cost information more effectively than traditional representation methods. The followings are the objectives to achieve the aim of this study,

1) Identify the problems in prevailing representation methods
2) Examine the applicability of Concept Map technique to represent information
3) Types of benefits provided by the Concept map technique

2. Literature Review

2.1 EFFECT OF COST INFORMATION

Cost information has a significant impact on any business environment, including the construction industry (Robson et al., 2016). According to Ibrahim and Mohamed (2021), construction clients prioritise accurate cost information for any given project. Cost information can be derived from historical data, similar projects, or ongoing projects, as well as through various other methods (Elmohr et al., 2022). Therefore, understanding building cost information is crucial for clients to make informed and accurate decisions regarding a project.

Different types of cost information are used at different stages of a construction project to inform client decisions. For example, according to the RIBA Plan of Work 2020, the "decision to build" is a strategic decision made by the client during the pre-design stage, influenced by feasibility factors such as technical, operational, economic, schedule, and legal considerations. Each of these factors significantly impacts the decision of whether to proceed with the project. The economic feasibility factor, in particular, focuses on the potential value of the project, with the general rule that the profit from the project should always outweigh the cost (Volden, 2019). This process often requires a substantial amount of historical and current cost information to evaluate and analyse the economic viability in relation to the client's requirements. Therefore, the impact of cost information on the economic feasibility of a project is critical, as it directly influences the strategic "decision to build."

However, according to the RIBA Plan of Work 2020, "implementing organizational structure" is another strategic decision made by the client within the project. Establishing an organizational structure ensures that the project meets its deadlines within the budget and determines the best way to assign responsibilities to project team members (Ehab et al., 2013). Cost information has less influence on the decision and implementation of an organizational structure because this decision is primarily driven by factors such as staff responsibilities, skill levels, levels of authority, available resources, and time constraints. Therefore, the impact of cost information on the strategic decision regarding the "organizational structure" is minimal.

These examples demonstrate how cost information can significantly influence some strategic decisions throughout the project lifecycle. However, there is a high risk of project failure if relevant stakeholders do not accurately assess the impact of cost information at different stages of a construction project. Therefore, presenting cost information to stakeholders in a comprehensive manner is crucial during each stage of the project.

2.2 PREVAILING COST INFORMATION REPRESENTATION METHODS

Historically, the Bill of Quantities (BOQ) has been the most commonly used method for representing cost information related to construction projects (Razali et al., 2016). Based on the study by Razali et al. (2016), BOQ existed in some form or another as far back as when the Egyptian pyramids were being constructed. This historical continuity contributes to BOQ's current acceptance as the most successful method for cost representation (Razali et al., 2016). Furthermore, there are currently no better alternative representations to replace the BOQ, and parties have adapted to using the BoQ rather than attempting to adjust it according to their needs (Luyue et al., 2022). BOQ is a standardised method for presenting cost data designed to follow a consistent format and cater to a specific group of stakeholders (Razali et al., 2016). However, using the same method to represent information may not be the most effective way to present cost details to all stakeholders. Therefore, while BOQ is an effective method for representing cost information, it may not be the most appropriate approach for conveying this information to every key stakeholder.

2.3 IMPORTANCE OF EFFECTIVE REPRESENTATION OF INFORMATION

The human brain is capable of encoding, modifying, and storing information obtained through different sensory organs and converting that information using a process called "thinking" to produce various kinds of outputs (Luppi et al., 2024). Different people can interpret a particular object from different perspectives because individuals have different thoughts. These perspectives are known as mental representations.

"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).

Hebart et al. (2020) explain that humans may assign diverse mental representations to a single object. For instance, the word "car" refers to a discrete object, yet different individuals may imagine it in various ways, such as a red car, a roofless car, or a Ferrari. These visualisations are heavily influenced by a person's background, education, experience, culture, position, expectations, and other factors that shape their understanding of objects in daily life (Luyue et al., 2022). Better understanding provides a clearer view of mental representation, as it is a psychological process related to both abstract and physical objects (Luyue et al., 2022). It creates a link between thinking and the use of concepts to interact with those objects (Hebart et al., 2020).

Various theories and techniques are used to enhance the understanding of the relationships between objects and concepts, as well as the connections among concepts themselves. Concept Map is one of the most widely utilised graphical information representation techniques, developed based on specialised psychological theories introduced by various individuals worldwide (Wang, 2019). This technique plays a critical role in different fields, such as medicine, teaching, lecturing, and engineering (Piá et al., 2011). However, the construction industry has been reluctant to adopt this technique for interpreting building-related information instead of relying on traditional methods. Given that the Concept Map technique is well established in other industries, it would be useful to investigate its potential impact if adopted in the construction industry.

2.4 CONCEPT MAP

Concept Map is a powerful teaching and learning technique developed by Professor Joseph Novak, based on Ausubel's cognitive theory of meaningful learning, which asserts that "the most important single factor influencing learning is what the learner already knows" (Novak & Canas, 2007). According to Bryce and Blown (2023), meaningful learning involves matching a person's experiences and concepts with new knowledge in an explicit and conscious manner. Novak and Canas (2007) stated that when meaningful learning techniques are used to understand an idea or concept, they alter human thinking patterns by restructuring existing concepts and linking them to new knowledge.

Ausubel initially proposed this theory for higher-level professionals who make their own decisions and noted that these individuals differ from others because they selectively link important details and ideas, creating various overviews and summaries (Bryce & Blown, 2023). Ausubel et al. (1978) describe these higher-level professionals as a "subsuming bridge" between new knowledge and existing concepts. Ausubel et al. (1978), emphasize that to understand any concept, it must be potentially meaningful, and the individual must properly connect it to their prior knowledge. There are two major types of understanding: "understanding concepts or objects" and "understanding principles," which explain how things change. Ausubel's theory focuses on understanding concepts by developing connections with prior knowledge (Ausubel et al., 1978).

Based on Ausubel's studies, Novak introduced a new learning technique, now known as "Concept Mapping." A Concept Map is used as a graphical tool to organise and represent knowledge (Novak & Canas, 2007). Bryce and Blown (2023) state that visually representing information through Concept Mapping helps individuals develop a better understanding of the knowledge domain.

Concept Map consist of concepts that are typically shown using regular shapes such as boxes, circles, or other forms, and the relationships among these concepts are indicated by lines that link them (see Figure 1). According to Novak and Canas (2007), words on these lines are known as linking words or linking phrases, and they describe the relationship between two concepts. Novak and Canas (2007) further define a "concept" as a "perceived regularity or pattern in events or objects, or records of events or objects. When two concepts are connected by linking words, the unit formed is known as a proposition (Novak & Canas, 2007). For example, the red-coloured box in Figure 1 creates the proposition "Organized Knowledge includes associated feelings or Affect" by linking the two concepts "Organized Knowledge" and "Associated feelings or Affect" using the linking word "includes."

Piá et al. (2011) states Concept Map can be applied to any discipline and Tolentino and Amélia (2020) mentions Concept Map is aiding to develop the critical thinking and habits of minds. Further, Tolentino and Amélia (2020) state that Concept Mapping involves the use of cognitive skills, such as analysis, assessment, and critical reasoning, making it a valuable tool for developing critical thinking skills in users. Thus, Concept Mapping has the potential to be an effective tool for representing cost information, enabling users to make accurate and informed decisions.

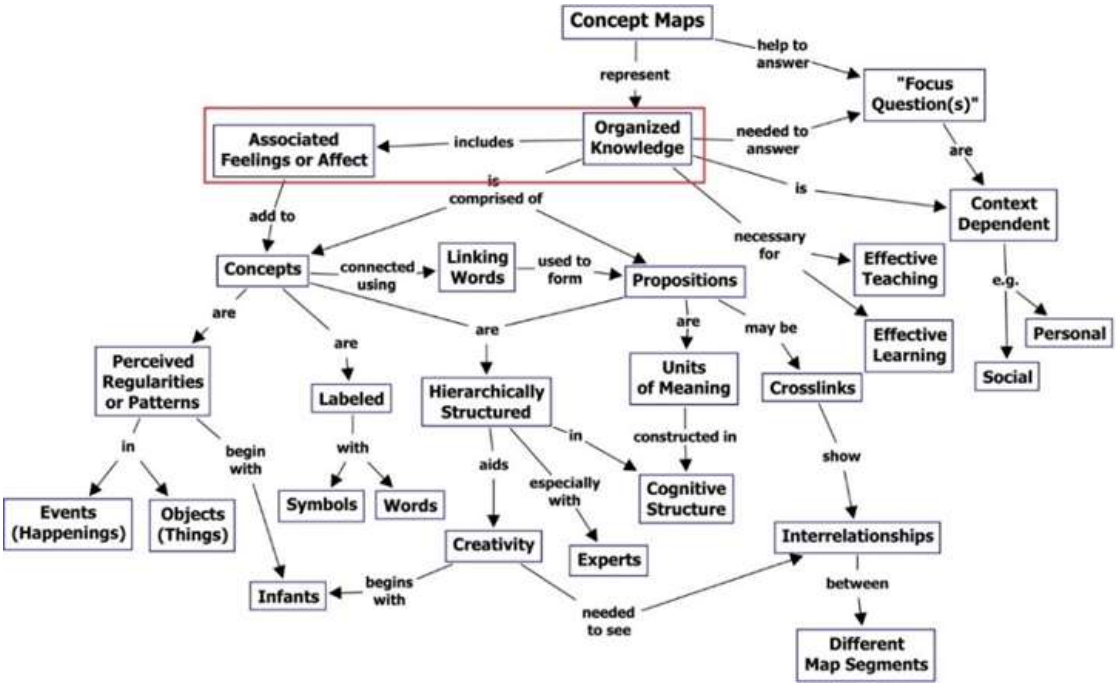

Figure 1: Concept Map Diagram
Source: Novak and Canas (2007)

3. Method

According to Ugwu and Eze (2023), a qualitative research approach focuses on understanding the deeper meaning behind people's feelings, ideas, and experiences, emphasising the rich descriptive insights that arise from personal and contextual interactions, rather than numerical data. This study aimed to explore the potential of using the Concept Map technique to represent cost information more effectively than traditional representation methods. Thus, a qualitative research approach was adopted to explore different stakeholders' experiences and opinions when they were given an opportunity to make a strategic decision using the developed Concept Map which represents building cost information.

The research is limited to the perspectives of Clients, Engineers, Quantity Surveyors, and Architects, as these stakeholders are primarily involved from the inception to the completion of a project. The sampling frame for this study consists of the aforementioned stakeholders (Clients, Engineers, Quantity Surveyors, and Architects), who have a minimum of 10 years of experience in construction procurement in Sri Lanka. For the analysis, participants were selected based on their specialty in construction procurement and years of experience in the area of construction procurement. Therefore, nonprobability sampling was chosen as the main sampling technique. According to Nyimbili and Nyimbili (2024), the purposive or judgmental sampling technique is used when a specific set of people needs to be selected intentionally to acquire important information that cannot be attained from other choices. Therefore, the purposive or judgmental sampling technique was chosen as the main sampling technique.

Further, Hennink and Kaiser (2022) stated that the sample size for saturation in qualitative research conducted using interviews is between 9-17 respondents. Thus, 20 professionals (5 from each stakeholder group) were invited to participate in the data collection process. Of the 20 professionals, 16 participated in the data collection process. Because the semi-structured interview process permits researchers to extract in-depth information from interviews while maintaining the focus of the research (Saunders et al., 2019), they were chosen as the best approach to collect data.

The interview guidelines were prepared according to the expert interview guide given by Taherdoost (2022). This interview session aims to explore the current methods of cost information representation and their limitations, assess the applicability of Concept Mapping as an innovative approach for representing cost information, and identify the potential benefits derived from its use. Thus, the following steps were followed to conduct expert interviews. Initially, a financial feasibility report was created for a hypothetical construction project to represent cost information using the traditional method. At the same time, the information in the financial report was described using a Concept Map. Subsequently, semi-structured interviews were conducted with respondents to understand the differences between the two techniques. During the interview, both the report and the Concept Map were provided to the respondents, who were then asked to compare the effectiveness of each method for information representation.

According to Klaus (2004), content analysis is a powerful tool for systematically examining textual, visual, and verbal data. By quantifying elements such as words, themes, or phrases, content analysis reveals the frequency and context of specific information while providing meaningful insights (Klaus, 2004). Therefore, content analysis was conducted to

identify recurring opinions from experts regarding the use of the Concept Map technique for representing cost information and to reach the study's findings.

According to Jacisa (2022), the most critical stakeholders in construction are the client and project team. Therefore, this study focuses solely on the perspective of the procuring party (i.e. the client and their consultants). To gather relevant insights, the researchers interviewed 16 respondents from the procuring entity, all of whom had over 10 years of experience in the construction industry. The profiles of the respondents are as follows (see Table 1),

Table 1: Respondent's profile

Professional Category	Respondent Nr	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

4. Findings and Discussions

This section details the main research findings and provides in-depth discussions addressing the research aim.

4.1 PROBLEMS IN PREVAILING REPRESENTATION METHODS

According to the respondents, various methods are used to obtain cost information, depending on the specific application of the information. The respondents noted that Bill of Quantities (BoQ), quotations, and reports are the most commonly used methods for acquiring cost information. Although these methods provide different types of cost information for each party, there are similarities in how cost information is represented. Table 2 illustrates the techniques used to represent the cost information within these methods.

Table 2: Conventional cost information representation methods

Method	Method of Representing Cost Information		
	Tabular	Descriptive	Graphical
BoQ	✓	✓	X
Quotation	✓	✓	X
Report	✓	✓	✓

According to Table 2, tabular and descriptive formats are frequently used to represent cost information. Juszczyk et al. (2017) also confirmed the descriptive and tabular nature of the BoQ to represent the cost information. This means that although parties may view cost information from different perspectives, they often rely on tables and descriptions to obtain their final output. Additionally, it may be challenging to draw conclusions on significant decisions owing to the limitations inherent in these formats. These intrinsic limitations were explained by the respondents during the interview process and few of highlighted statements are mentioned in below,

Respondent C02 states, *"When we compare quotations, we have to keep them all together and go through each page to find the needed information, which makes it difficult and time-consuming."*

Respondent E01 states, "*Traditional methods do not give me direct access to the cost information; If I need some information, I might have to navigate page to page find such information. So, I don't think it's an efficient method*."

Respondent A02 states, "*While we can't disregard the current methods, as an architect, I'd appreciate getting an overall view at a glance—something the prevailing methods don't provide*."

Respondent C01 states "*Before sharing any documents, it is essential to consider the audience. I doubt most non-technical people would fully understand the contents of a BoQ*."

Respondent QS01 stated, "*Industry professional like us with years in the construction industry, using methods like BoQs and quotations is no problem. However, for someone less familiar, such as an investor, these documents can be technical and time-consuming. They would likely prefer a summary format, with something like a graphical method to capture the essentials at a glance. However, graphical type of methods isn't commonly used in our industry yet.*"

Respondent C04 states, "*I find the BoQ isn't very user-friendly. It doesn't follow the construction sequence, so it's tough to go directly to the information we need*."

A summary of these intrinsic limitations according to respondents is provided in Table 3.

Table 3: Limitations of the prevailing cost information representation methods

No	Problems in prevailing methods	Respondents
1	Difficulty of comparing cost information	C01, C02, C04, A02, A04, E01 E03, E04, QS01, QS02, QS03
2	Difficulty of direct accessing to different levels of cost information	C02, C03, A01, A02, E01, E02, QS01, QS02
3	Difficulty in grasping the overall idea of cost information at once	C01, C02, C03, A01, A02, E01, E02, E03
4	Need to have substantial technical knowledge about the method. Ex: use of BoQ	C01, C02, C03, C04, A01, A02, A03
5	Difficulty of information summarization	C01, A02, A03, A04, E01 E03, E04, QS01, QS02, QS03, QS04
6	Lack of graphical methods to represent cost information	C01, C02, C03, A02, A03, A04
7	Less user-friendliness	C01, C03, C04, A01, A02, A03, A04

4.2 APPLICABILITY OF CONCEPT MAP TECHNIQUE TO REPRESENT INFORMATION

Initially, respondent groups (client, architect, engineer, and quantity surveyor) were requested to refer to the given financial feasibility report and the Concept Map related to the economic feasibility of the proposed project. Later, respondents were questioned about the characteristic differences between the two methods when representing the cost information. Responses in each group are summarised below.

4.2.1Client's point of view

According to the client group, many clients lacked familiarity with technical terminology, which could significantly hinder their understanding when using descriptive reports to grasp cost information. Due to the large number of technical terms in these reports, clients may struggle to obtain a clear picture of what is expected. C02 answer explain aforementioned concerns by stating, "*When we use a BoQ or quotation to get cost information, it often includes a lot of technical terms, which can make it hard to understand and easy to get lost in the details*." However, C02 further states, "*As a non – technical person I think Concept Map is better method, because it's using a graphical representation and it contains only few words. So, it helps to grab cost information easily.*" Concept Map only uses a few words and since C02 argued it is easier and quicker when grasping the underlying ideas. This aligns with Schmidt et al. (2024), who explain that concept maps solve problems in technical systems by showing the relationships between concepts in a graphical manner.

Furthermore, C01 stated, "*As a client, I just need the most critical cost information to make my decisions. However, with traditional methods, I am often flooded with so many details, and it can be tough to connect the dots and make a clear decision. However, Concept Map can summarise all the information to one single view, which is not complicated to understand and identify any significant errors in cost figures based on my knowledge*." C01's statement explains that reports may provide more detailed information than a Concept Map. This information is often dispersed across numerous descriptions, making it challenging to consolidate and link relevant details. In contrast, a Concept Map presents all links and related cost information in a single view, allowing for easier recognition and identification of any errors in cost figures. C01's idea was further confirmed by Cañas et al. (2005), who mentioned that concept maps represent information in a way that makes them easily browsable by improving the searching process more efficiently.

4.2.2 *Architect's point of view*

According A03, "*a concept map can show all the cost information on one sheet, making it really easy to grab the details. Unlike a report, we don't have to flip through pages."*A03's idea explains that creating a concept map on a single page by consolidating all relevant details into a compact area is the most impactful benefit of the concept map compared to the traditional reporting method. The compact nature of the Concept Map facilitates quick comprehension and can save time when making decisions. Additionally, A03's statement highlights the benefit of limiting navigation through pages to extract information, which can save user time. This idea was further highlighted by A04, who stated, *"The concept map provides*

direct access to the relevant cost figures." A04's idea explains that the Concept Map allows users to quickly access the necessary information from a limited space.

A01 inline the unique characteristic of their profession with the Concept Map by stating, "*Since we're architects, we prefer to see information in a more graphical format and the Concept Map can provide it.*" According to A01, architects, who typically work with designs, models, and drawings, may be reluctant to sift through reports to find the required cost information. In such cases, a Concept Map serves as an effective alternative for accessing cost information. Furthermore, the Concept Map's streamlined format can aid in making urgent decisions owing to its minimal reading requirements.

4.2.3 *Engineer's point of view*
The E03 stated that "*The key benefit I see in the concept map is that it limits the need to navigate through pages to access the key information."* E03's idea reveals that a Concept Map provides more direct access to information, as all the required cost details are contained within one or two pages. This allows users to view all cost information simultaneously, rather than navigating through multiple documents. In contrast, a report requires sequential access, meaning that users must read through the file from the beginning in the order it was prepared. According to the respondents, the Concept Map facilitates immediate and random retrieval of data related to any part of the project. Therefore, E03 considers the Concept Map to be a more effective technique for representing cost information in urgent situations compared to a traditional report.

However, the engineer group highlighted some drawbacks in the Concept Map compared to the traditional reporting method. E01 states, "*Even though I think this technique is better, some technical people might have an issue with it because of the informal way the cost information is presented. Most technical people are used to receiving cost information in a more formal format, so this approach might not be accepted by all of them due to its informality*." Even though the concept map method makes it easy to obtain information, most professionals are habituated to using a formal format to receive cost details. As a result, there could be challenges in convincing technical people to adopt this informal method. E01 indirectly highlighted the need for a cultural shift before implementing the concept map technique within the industry.

4.2.4 Quantity surveyor's point of view
QS01 explained the hierarchical nature of the Concept Map by stating, "*With a concept map, we can provide different levels of cost information for different groups. For example, most clients will make decisions based on the major cost elements and will not want to dive into the subcategories of those elements. However, as a quantity surveyor, I would go through the subcategories to understand the cost breakdown of each element*."

According to QS01, the Concept Map features a top-to-bottom hierarchy (see Figure 2), allowing users to view different levels of information clearly. In contrast, the report includes detailed information about the project, which can be extensive. Therefore, in Concept Map, users can select the preferred level of detail to obtain cost information, eliminating the need to review all information as required when reading a report. The level of detail in the Concept Map depends on the user's requirements, enabling them to build up the cost from the selected level to the top to determine the ultimate cost figure. According to Schmidt et al. (2024), this hierarchical accessing is known as functional abstraction, and this is one of the key characteristics of the Concept Map technique. More precisely, in functional abstraction, the higher levels explain why the lower levels are necessary, and the lower levels explain how the higher levels are realised (Schmidt et al., 2024).

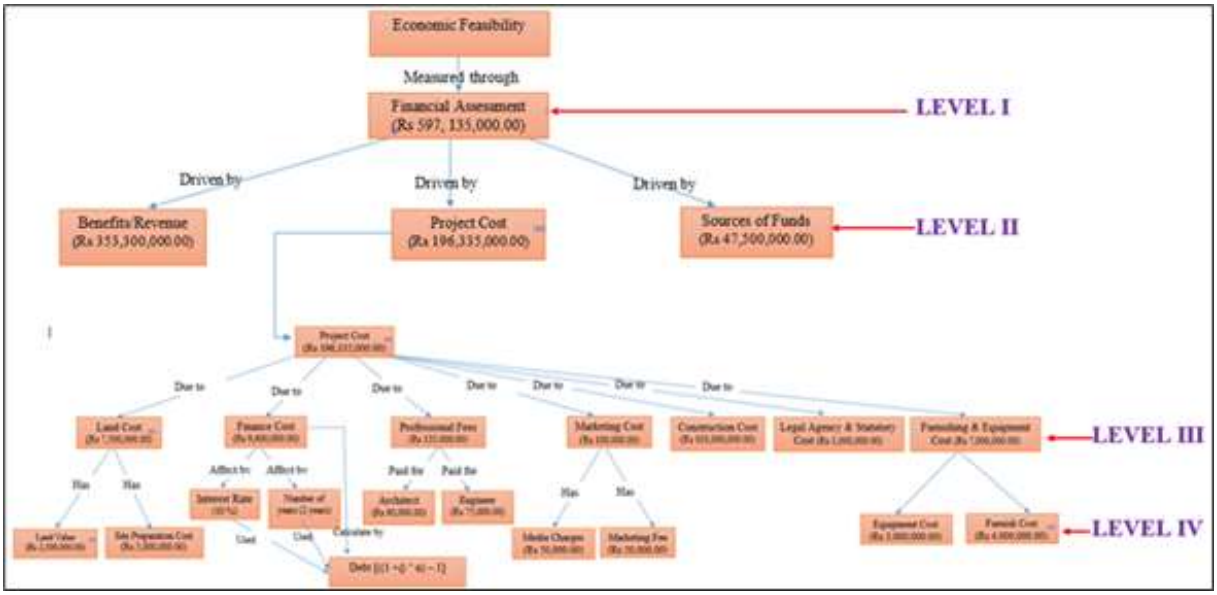

Figure 2: Top to-bottom hierarchy in the Concept Map

QS03 states, "*There can be situations where the sum of the costs for subdivided works does not match the final total. These errors are much easier to spot using the Concept Map technique compared to traditional reports.*" According to QS 03, it is easier to cross-check the accuracy of cost figures when they are broken down into subparts. Additionally, users can modify the sub-cost figures and observe their impact on the final cost figure and its accuracy.

Like other groups, the quantity surveyors also mentioned that the Concept Map includes graphical content, which users can grasp more easily than descriptive paragraphs. Graphical representation facilitates easier analysis of the content compared to textual descriptions. This format allows users to quickly identify and correct errors because the visual layout makes it easier to identify inaccuracies and update them immediately.

According to the respondents' opinions, Table 4 summarises the differences between the Concept Map and convention report when representing the cost information.

Table 4: Difference in information representation using the Concept Map technique and the conventional report

Nr	Report	Concept Map Technique	Respondents
1	Sequential access	Direct access	C01, C02, A01, E03
2	Descriptive version	Summarized version	C01, C02, C03, C04, A01, A03, E04
3	Cost build-up is not visible	Cost build-up is visible	C01, C02, C03, C04, A01, A02, A03
4	Textual representation	Graphical representation	C01, C02, C03, C04, A01, A02, A03, E01, E04, QS01, QS02, QS04
5	Information is disseminated on different pages	All required information is within one or two pages	C03, E03, E04, Q03, Q04
6	Comparison of cost figures takes more time	Comparison of cost figures takes less time	C01, C02, C03, C04, A01, E02, E04, QS02, QS03
7	Navigation through information takes more time	Navigation through information takes less time	C01, C02, C03, C04, A01, E03, E04, QS02, QS03
8	Contain more information	Contain less information	C01, C02, C03, C04, A02, A04
9	The hierarchy of cost build-up cannot be seen	Top-to-bottom hierarchy	C02, A01, A04, E01, QS01, QS02, QS04
10	No need to have cultural adaptation	No need to have cultural adaptation	E01, QS03

4.3 BENEFITS SEEK FROM INNOVATIVE REPRESENTATION METHODS

The respondents were further questioned about the benefits they sought from innovative methods. Table 5 shows a summary of the respondents' answers and examines how many of those benefits can be achieved by the Concept Map technique based on their answers in the previous section.

Table 5: Benefits received from the Concept Map

Process Method	Benefits seeking from innovative information representation methods	Concept Map
Compare	cost of different stages of the project	**Yes**
	cost of Alternative designs	**Yes**
	cost of alternative items within one design	**Yes**
	cost of alternative materials with usage	**N/A**
	cost of different systems with usage	**N/A**
	cost of alternative materials against specific attribute	**N/A**
Develop	cost analysis	**N/A**
	Budget for construction project	**Yes**
	cost breakdowns of certain BOQ items	**Yes**
	cost of design according to the budget	**Yes**
Group	elements under the given criteria	**N/A**

5. Conclusions

This study investigates the effectiveness of Concept Maps in representing cost information compared to traditional methods. The research involved creating both a conventional financial feasibility report and a Concept Map for a hypothetical construction project. The effectiveness of these two methods was then evaluated through semi-structured interviews with clients, engineers, architects, and quantity surveyors.

This study highlights that traditional methods of presenting cost information, such as BoQs, quotations, and reports, have inherent limitations. The research participants identified challenges such as difficulty in comparing costs, accessing varying levels of detail, summarising information, and overall user-friendliness. Furthermore, the study reveals the key differences between conventional information representation methods and Concept Maps. Finally, it discusses the benefits that

respondents seek from innovative information representation methods and evaluates how many of these benefits are achieved through the use of Concept Maps for representing cost information.

This study had two main limitations. First, while Concept Maps are useful for visualising complex relationships, they may oversimplify construction cost data, potentially omitting critical variables relevant to real-world projects. This limitation arises because the research approach did not account for the complexity or specific nature of projects where cost information is presented through Concept Maps. Second, researcher bias may have influenced the creation of the Concept Maps, as their structure and presentation could reflect the researcher's interpretation of the data, potentially affecting how respondents understood and answered the questions. These factors suggest that while the study provides valuable insights, its conclusions should be interpreted with caution and may not be widely applicable to all construction projects.

As a future direction, this study suggests that integrating the Concept Map technique with 5D BIM could further optimise the representation of cost information, surpassing the effectiveness of traditional methods. Given that BIM plays a crucial role in representing and exchanging building information among stakeholders, this integration could enhance the overall efficiency of representing cost information.

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