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Interpretive Structural Modelling of People Capability Factors to Promote Sustainable Facility Management Practices

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Abstract: Sustainability has become a crucial notion to be pursued throughout the life-cycles of project development, particularly during the post construction involving the Facility Management (FM) function. At the forefront of sustainable practice, FM professionals can apply a great deal of influence through operational and strategic management and therefore demand them to be empowered with the necessary knowledge, capabilities and skills. In the preliminary study reported separately, 23 critical people capabilities factors have been identified to support the sustainability measures in facility management practices. Through pairwise comparison study and Interpretive Structural Modelling (ISM) technique, this research further investigates the interrelationships between these critical factors, identifies the level of influences of each factor and propose a hierarchical structure that would enable FM professionals to take appropriate steps as an effective solution for the promotion of sustainable FM. The developed ISM Model shows that almost all of the people capability factors are interrelated and cannot be achieved in isolation. However, "familiar with the building system" factor and "understand the design and construction issues related to FM practice" factor have a high driving power and both of these factors contribute to the sustainability agenda in the strategic capability category. This analysis provides a directions for FM professionals to decide and differentiate between the independent and dependent factors and help them to focus on the enhancement of those people capability factors that are most important to support sustainable FM practices.

Key words: Capabilities, facility management, Interpretive Structural Modelling (ISM), sustainability, agenda

INTRODUCTION

The construction industry is facing major environmental challenges worldwide due to its significant impact to the environment. To generate an effective built environment and achieve sustainable construction along the project life-cycle, more attention should be paid to the occupancy phase. This effort can be carried out through the implementation of sustainable practice in building operations and maintenance activities. An emphasis on the sustainability issue during this phase is crucial based on its impact on the Life-Cycle Cost Analysis (LCCA) of a building, as well as its potentially detrimental impact on the environment (Hodges, 2005; Prasad and Hall, 2004; CIOB, 2004).

Presently, there is an emergent interest among facilities managers and building owners to integrate sustainability measures into the management of built assets. This scenario is supported by the fact that FM personnel are in a unique position to view the entire process and influence the entire life-cycle of a facility. Facilities managers can also create long-lasting value for an organization by developing, implementing and maintaining sustainable FM practices since they are armed with the proper financial and strategic planning tools (Hodges, 2005). Furthermore, past research suggests that the implementation of sustainability measures in FM activities can deliver benefits such as reducing energy consumption and waste, while increasing productivity, financial returns and standing in the community (Hodges, 2005; Lai and Yik, 2006).

However, despite the growing awareness of sustainability in the FM sector, very few managers and building owners positively embrace the ideas and implement them in their operations. This is due to the early stage of the sustainable development concept in FM

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Table 1: Structural self-interaction matrix (SSIM)

Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	-	X	V	O	A	X	O	O	X	X	V	X	O	V	X	O	O	X	V	X	V	A	X
2	-	-	V	O	V	X	O	O	X	V	V	A	A	O	X	O	O	O	V	V	X	X	O
3	-	-	A	O	A	O	A	X	X	A	X	X	O	X	O	X	A	O	O	O	O	O	
4	-	-	-	-	X	X	X	X	O	O	O	O	O	X	X	A	A	X	X	O	O	A	X
5						A	O	X	X	X	X	X	O	X	X	O	O	A	A	X	X	X	X
6							V	O	O	X	X	O	O	X	O	O	O	O	X	O	O	X	O
7								A	X	O	O	O	O	X	X	A	A	X	X	O	X	O	A
8									V	V	X	X	X	X	X	X	X	X	X	A	A	A	V
9										X	X	X	O	X	V	O	O	V	A	V	V	X	V
10											V	A	A	A	V	X	O	V	X	V	V	A	X
11												A	A	A	A	O	O	A	A	A	A	A	A
12													X	X	V	O	O	X	X	X	V	A	V
13														O	V	O	V	V	V	V	V	V	V
14															V	X	V	V	V	V	V	V	V
15																A	A	X	X	V	V	A	A
16																	X	V	O	O	O	O	X
17																		X	A	O	A	A	X
18																			A	X	X	X	A
19																				X	X	X	A
20																					X	X	A
21																						A	A
22																							V
23																							

practices, leading to a lack of the understanding and skills required to put it into action (Elmualim *et al*., 2010). Previous studies have identified various factors such as capabilities, knowledge and organizational issues as the barriers that inhibit sustainability implementation. Capabilities issues in achieving sustainability in FM including the lack of professional capability, capabilities discrepancies and skills and capabilities magnitude have been emphasized in several extant research studies as being crucial challenges that need to be addressed in an effort to promote sustainability (Hodges, 2005; Shah, 2007; Shafii *et al*., 2006). In addition, issues such as the lack of sustainability knowledge, knowledge chasm and challenges faced in the knowledge transfer process have been highlighted (Abbas *et al*., 2009; Elmualim *et al*., 2010; Shah, 2007; Jensen, 2009). Moreover, the unwillingness of FM personnel and organizations to adopt new routines to implement sustainability in their business also contributes to current drawbacks.

In this context, there is a need for better understanding of the potential for enhancing the capabilities of FM personnel before the wider adoption of sustainability can be expected. Capabilities and skills are regarded as the key enablers in dealing with the sustainability endeavours of an organization. They are also vital to the fostering of competency in an organization so that it can innovate in a more sustainable way and vital to support the sustainability agenda in an organization (Kleef and Roome, 2007; Gloet, 2006). Currently, research that focuses on soft issues such as people's capabilities and skills is still lagging behind the efforts of developing guidelines, technical manuals and knowledge portals. Therefore, it is beneficial to explore the capability issues in order to support the implementation of the sustainability agenda in Facilities Management (FM) practices.

In the preliminary study, Sarpin and Yang (2013) examined the people capability factors in general that could promote sustainable practice application through literature review and then compared this to the specific characteristics of facility management practices. FM Industry practitioners were asked to complete a questionnaire survey to establish each variable's probability of occurrence and level of significance to support sustainable FM. Data collected from the questionnaire survey was statistically analysed by using SPSS Software. The analysis revealed twenty three critical people capability factors that will serve as a basis for the establishment of the mechanism to equip FM professionals with the right knowledge, to continue education and training and also to develop new mindsets to support sustainable FM. These critical factors cover a wide range of aspect such as understand life-cycle cost analysis concept, develop good relationship with the organization's top management and a vision for a better future. While details of this study are separately reported, results from the preliminary study are shown in Table 1.

Based on the earlier findings, this study presents further research investigating the interrelationships between the critical people capability factors in order to better understand of each factor's level of influence in promoting sustainable FM practice. This study first reviews the identified people capability factors to support sustainability measures in FM practice. Followed by the introduction of a pairwise comparison study and Interpretive Structural Modelling (ISM) analysis. This then leads to the establishment of ISM based model for people capability factors. The key findings from the model and analysis are then discussed.

Literature review: The issue of limited capabilities to achieving sustainability goals in the FM sector has been highlighted as a barrier that needs solutions (Shah, 2007; Shafii *et al*., 2006; Hodges, 2005). This situation has led to more concerted efforts towards sustainable development since the involvement of FM functions is required especially in activities with an environmental and economic focus. For this reason, facility managers need to understand how the growing importance of sustainability is affecting the way they execute their roles and responsibilities. FM personnel must become professionally competent and knowledgeable about the sustainability issues that will impact on their business environment both operationally and strategically (Elmualim *et al*., 2010).

A background review was conducted to understand the People Capability (PCap) factors that would impact on the consideration of sustainability measures in facility management practice. This understanding contributed to the establishment of a mechanism to allow FM professionals develop new mind-sets in order to uplift their performance in delivering sustainability. This will also help them identify knowledge deficiencies and skill gaps for continuing education and training. Sixty people capability factors were identified from the existing literature of related studies to obtain a holistic view of people capability factors in the promotion of sustainability agenda. These factors cover a wide range, such a understand life-cycle cost analysis concept, develop good relationship with the organization’s top management and a vision for a better future. Based on these factors, a theoretical knowledge base can be developed to guide the data collection and analysis for in-depth research.

These sixty factors were sorted into five micro-categories based on the Wiek and coauthors classification for a similar application, namely: interpersonal capability; system thinking capability; anticipatory capability; normative capability and strategic capability. In this research context, interpersonal capability relates to enabling FM personnel to solve issues and respond to challenges of sustainability applications. System thinking is about being able to analyse complex systems across three different pillars of sustainability and over different scales. Anticipatory capability will facilitate analysis and evaluation of sustainability actions and consequences. Normative capability is to map, apply and resolve sustainability values and principles in a person that should either be discarded or maintained to sustain the balance of nature. Finally, strategic capability will contribute to specific sustainability implementation strategies in an organisation.

The critical people capability factors identified based on questionnaire survey was summarised in this Table 1. The identified critical factors were categories under four categories strategic capability, anticipatory capability, interpersonal capability and system thinking capability. None of the people capability factors to do with normative capability was considered as significant factors in order to enhance the sustainability effort in FM since all of these factors have a mean score <4.0.

Critical people capability factors for supporting sustainability measures in FM practices

People Capability (PCap) factors; strategic capability:

- Understand the LCC and TCO technique
- Understand whole-life value concept
- Develop good relationship with the organisation's top management
- Understand the organisation’s financial strategy
- Ability to optimise the building space
- Understand the design and construction issues related to FM practice
- Familiar with the building system
- Develop organisation's sustainability strategies
- Ability to monitor and maintain equipment efficiency
- Ability to specify the energy and environmental goals to associated stakeholders

Anticipatory capability:

- Take a long-term perspectives
- Identify short-term and long-term consequences of any decision/plan
- Vision for a better future
- Identify direct and indirect consequences to people and ecosystems

Interpersonal capability:

- Ability to work across disciplines
- Ability to motivate other stakeholders
- Self-motivated
- Communication skills
- Collaboration skills
- Ability to plan and implement sustainability efforts
- Courage to make changes

System thinking capability:

- Understand the meaning, goal and issues of sustainable development
- Understand the bigger picture of significant aspect of sustainable development

MATERIALS AND METHODS

The purpose of this study was to investigate the interrelationships between the critical people capability factors in supporting sustainable FM and identifies the level of influences of each factor. Then, a hierarchical structure that would enable FM professionals to take appropriate steps as an effective solution for the promotion of sustainable FM was proposed. The ISM method was applied as the main approach to fulfil the objective of this research.

ISM is a well-established interactive management tool that assists research by imposing order and direction on complex relationship among elements of a system (Warfield, 1974; Mandal and Deshmukh, 1994). The ISM process able to transform unclear and poorly articulated mental models of systems into a visible and well-defined model (Farris and Sage, 1975; Ahuja *et al.*, 2009). In ISM technique, a set of different and directly related elements are structured into a comprehensive systematic model. The model formed portrays the structure of the studied complex issue in a carefully designed pattern shown graphically as well as in words (Ravi and Shankar, 2005). The ISM methodology is 'interpretive' as the judgement of the group decides whether and how the variables are related, it is 'structural' as on the basis of relationship, an overall structure is extracted from the complex set of variables and it is 'modelling' as the specific relationships and overall structure are portrayed in a graphic form (Mandal and Deshmukh, 1994; Ahuja *et al.*, 2009). This technique is mainly intended as a group learning process but individual researchers can also apply it to identify structure in a system of related items. (Ravi and Shankar, 2005; Ahuja *et al.*, 2009). The various steps involved in the ISM method are as follows:

Step 1: Identify the elements (or variables) that are relevant to the complex system (or problem) which can be objectives, actions, individuals, etc.

Step 2: Establish a contextual relationship among variables with respect to which pairs of variables are examined.

Step 3: Formulate a Structural Self-interaction Matrix (SSIM) of PCap factors that displays the pair-wise relationships.

Step 4: Develop a reachability matrix based on the SSIM to calculate the numerical mutual influence, and then checking the matrix for transitivity. The transitivity of the contextual relation is a basic assumption in ISM which states that if element A is related to B and B is related to C, then A is related to C. This step will lead to the development of 'Final reachability matrix'.

Step 5: Partition the final reachability matrix obtained in Step 4 into different levels.

Step 6: Based on the relationships given above in the reachability matrix, draw a directed graph (digraph) and remove the transitive links.

Step 7: Convert the resultant digraph into an ISM-based model by replacing variable nodes with the statements.

Step 8: Review the model to check for conceptual inconsistency and make the necessary modifications.

In this research, a pairwise comparison study was conducted to identify the contextual relationship among the people capability factors in supporting the sustainability measures in FM practices. Five experts in FM sector were involved in the pairwise comparison study. There were rare discussion in existing research regarding the minimum number of experts and how to decide on the ideal size of expert group involved in the ISM processes (Iyer and Sagheer, 2009; Li and Yang, 2014). In order to ensure the consistency of the information, the experts who involved in this study were selected from the questionnaire respondents who also agreed to participate in the pairwise comparison study. These experts, each have >15 years of experience in the area of facility management and holding senior position in their respective organization.

The pairwise comparison study was conducted to develop an understanding of the relationship between the 23 PCap factors. These experts were asked to deal with two factors at a time. The number of questions involved in this study was calculated using N(N-1)/2 where N is the number of factors between the relationships will be investigated. Since, there were 23 PCap factors, the number of questions was 23(23-1)/2 = 253. Thus, the experts were requested to compare and complete 253 pairwise comparisons. Once the individual responses from experts were obtained, the Delphi technique was applied to indicate the consensus among all the respondents. The mode of each pairwise comparison was calculated where mode values of 60% indicated strong agreement among all respondents. In the first round, out of 253 pairwise comparisons, 181 had mode values of 60%.

Table 2: Initial reachability matr

Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	1	1	1	0	0	1	0	0	1	1	1	1	0	1	1	0	0	1	1	1	1	0	1
2	1	1	1	0	1	1	0	0	1	1	1	0	0	0	1	0	0	0	1	1	1	1	0
3	0	0	1	0	0	0	0	0	1	1	0	1	1	0	1	0	1	0	0	0	0	0	0
4	0	0	1	1	1	1	1	1	0	0	0	0	0	1	1	0	0	1	1	0	0	0	1
5	1	0	0	1	1	0	0	1	1	1	1	1	0	1	1	0	0	0	0	1	1	1	1
6	1	1	1	1	1	1	1	0	0	1	1	0	0	1	0	0	0	0	1	0	0	1	0
7	0	0	0	1	0	0	1	0	1	0	0	0	0	1	1	0	0	1	1	0	1	0	0
8	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1
9	1	1	1	0	1	0	1	0	1	1	1	1	0	1	1	0	0	1	0	1	1	1	1
10	1	0	1	0	1	1	0	0	1	1	1	0	0	0	1	1	0	1	1	1	1	0	1
11	0	0	1	0	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
12	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	1
13	0	1	1	0	0	0	0	1	0	1	1	1	1	0	1	0	1	1	1	1	1	1	1
14	0	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	0	1	1	0	0	1	0	0	0	1	0	0	1	1	1	1	0	0
16	0	0	0	1	0	0	1	1	0	1	0	0	0	1	1	1	1	1	0	0	0	0	1
17	0	0	1	1	0	0	1	1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	1
18	1	0	1	1	1	0	1	1	0	0	1	1	0	0	1	0	1	1	0	1	1	1	0
19	0	0	0	1	1	1	1	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1	0
20	1	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	0	1	1	1	1	1	0
21	0	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	1	1	1	1	1	0	0
22	1	1	0	1	1	1	0	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1
23	1	0	0	1	1	0	1	0	0	1	1	0	0	0	1	1	1	1	1	1	1	0	1

In the second round, the remaining 72 comparisons were taken back to the respondents indicating the low level of agreement. All 5 respondents were participated in the second round and they were asked to revise their responses. After the second round, the respondents had an agreement for 53 pairwise comparisons. The majority opinion was taken for the remaining 19 pairwise comparisons due to time constraint.

Interpretive Structural Modelling (ISM) analysis

Structural Self-Interaction Matrix (SSIM): Based on the contextual relationship among the factors which were identified in the pairwise comparison study, the next step was to define these into a Structural Self-interaction Matrix (SSIM). This research used the contextual relationship of "will help achieve" where it indicates whether one factor will help achieve another factor. Experts were asked to compare the relationship between two factors, O_i and O_j. The following four symbols were used to denote the direction of relationship between two factors:

V: Factor i will help achieve factor j
A: Factor j will help achieve factor i
X: Factor i and j will help achieve each other
V: Factor i and j are unrelated

Table 2 shows structural self-interaction matrix with relationships between each pair of factors. It indicated the existence and nature of relationship between the 23 PCap factors. The following description explains each category of relationship V, A, X and O in the SSIM:

- The relationship between factor 1 and 11 is V. This means that factor 1 (Understand the LCC technique) will help achieve factor 11 (Ability to optimize the building space and equipment operations)
- The relationship between factor 1 and 5 is A. This means that factor 5 (Take a long term perspective) will help achieve factor 1 (Understand the LCC technique)
- The relationship between factor 1 and factor 6 is X. This means that factor 1 (Understand the LCC technique) and factor 6 (Understand the organizations' financial strategy) will help achieve each other
- The relationship between factor 1 and 7 is O. This means that factor 1 (Understand the LCC technique) and factor 7 (Ability to motivate other stakeholders) are not related

Reachability matrix: The structural self-interaction matrix was then transformed into a binary matrix called the initial reachability matrix. This process was done by substituting the relationship denoted by V, A, X and O relationship with 1 and 0 as appropriate. The rules for the substitution of 1 and 0 are as follows:

- If (i, j) entry in the SSIM is V, then the (i, j) entry in the reachability matrix become 1 and the (j, i) entry become 0
- If (i, j) entry in the SSIM is A, then the (i, j) entry in the reachability matrix become 0 and the (j, i) entry become 1

- If (i, j) entry in the SSIM is X, then the (i, j) entry in the reachability matrix become 1 and the (j, i) entry also become 1
- If (i, j) entry in the SSIM is O, then the (i, j) entry in the reachability matrix become 0 and the (j, i) entry also become 0

Table 3 shows the initial reachability matrix. After the transformation from SSIM to initial reachability was done, then any transitive link that may exist between different variables need to be investigated and the final reachability matrix was established. The transitivity of the relationships is a basic assumption made in the ISM method. It states that if factor i influences factor j and factor j influences factor k, then factor i should influence factor k. The transitive link is applied to the factors which have no relationship (O).

In the final reachability matrix in Table 3, the driving power and dependence of each factor are also shown. The driving power of a factor is the total number of factors which it may help achieve including itself. The dependence of a factor is the total number of factors (including itself) which may be impacting on it.

Level partitions: From the final reachability matrix, the reachability set and antecedent set for each factor can be identified (Warfield, 1974). The reachability set for each factor consists of the factor itself and the factors it drives. The antecedents set consists of the factor itself and the factors on which it depends. Then, the intersection of these sets is derived for all the factors. The factor(s) for which the reachability and the intersection sets are the same are given the top-level in the ISM hierarchy. The factors in the top-level of hierarchy would not help achieve any other factors above their own level (Faisal 2010). After the top-level factors were identified, these factors are separated out from the other remaining factors (Ravi and Shankar, 2005). Then the same process is repeated to find out the factors in the next level until the level of each factor is identified. From Table 4, it is seen

Table 3: Final reachability matrix

Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Driving power
1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	21
2	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	21
3	0	0	1	0	1	0	1	0	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	16
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	1	20
5	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	19
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	22
7	1	1	1	1	1	0	1	0	1	1	1	1	0	1	1	0	0	1	1	1	1	1	0	17
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	20
9	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	21
10	1	0	1	1	1	1	1	0	1	1	1	0	0	0	1	1	1	1	1	1	1	0	1	17
11	0	0	1	1	1	1	1	1	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	10
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	22
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	23
14	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	22
15	1	1	1	1	1	1	1	1	0	0	1	0	0	0	1	0	0	1	1	1	1	0	0	14
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	23
17	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	1	0	0	1	18
18	1	1	1	1	1	1	1	1	0	0	1	1	0	0	1	0	1	1	0	1	1	1	0	16
19	0	0	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	18
20	1	0	1	1	1	1	1	1	0	0	1	1	0	0	0	1	1	1	1	1	1	1	0	16
21	0	1	1	1	1	1	1	1	0	0	1	0	0	0	0	1	1	1	1	1	1	0	0	14
22	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	21
23	1	1	1	1	1	0	1	0	0	1	1	0	0	0	1	1	1	1	1	1	1	0	1	16
D	18	17	23	22	22	19	23	18	18	18	22	17	11	13	20	19	20	20	18	21	20	13	15	

Table 4: Iteration I

Factors	Reachability	Antecedent	Intersection	Level
1	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23	1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 13, 15, 16, 17, 18, 20, 22, 23		
2	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23	1, 2, 4, 6, 7, 8, 9, 12, 13, 14, 15, 16, 17, 18, 21, 22, 23		
3	3, 5, 7, 9, 10, 12, 13, 14, 15, 16, 17, 17, 19, 20, 21, 22, 23	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20 21, 22, 23	3, 5, 7, 9, 10, 12, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23	I
4	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 18, 19, 20, 21, 23	1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23		
5	1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23		

Table 4: Continue

Factors	Reachability	Antecedent	Intersection	Level
6	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22	1, 2, 4, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22		
7	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 14, 15, 18, 19, 20, 21, 22	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 14, 15, 18, 19, 20, 21, 22	1
8	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 14, 15, 16, 17, 18, 19, 23	1, 2, 4, 5, 6, 8, 11, 12, 13, 14, 15 16, 17, 18, 19, 20, 21, 22,		
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16	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23	1, 2, 3, 5, 6, 8, 9, 10, 11, 12, 13, 14, 16, 17, 19, 20, 21, 22, 23		
17	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 16, 17, 18, 20, 23	1, 2, 3, 5, 6, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23		
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23	1, 2, 3, 4, 5, 7, 10, 11, 15, 16, 17, 18, 19, 20, 21, 23	1, 2, 3, 4, 5, 8, 9, 10, 12, 13, 14, 16, 17, 22, 23		

that Factor 3 "Ability to work across discipline" and Factor 7 "Ability to motivate other stakeholders" were found at Level 1. Thus, these factors are positioned at the top of the ISM model. Table 5 shows the level of each factors obtained after 6 iterations.

ISM-based model: The identified levels help in developing the digraph and the ISM model (Ravi and Shankar, 2005). Based on the level partitions of the factors and final reachability matrix, the initial diagraph including transitive link is obtained. After removing the transitivities, the digraph was finally converted into the ISM-based model (Fig. 1). The model reflects the interrelationships between the factor i and j, shown by an arrow which points from factor i to factor j. It is observed that the ability "understand the design and construction issues related to FM practices" (F12) and "familiarity with the building system manual" (F13) form the base of the ISM hierarchy and the "ability to work across discipline" (F3) and the "ability to motivate other stakeholders" (F7) are at the top. As shown in Fig. 1, it can be seen that F12 "understand the design and construction issues related to FM practices" which is placed in Level 6 can help in achieving F9 "understand the meaning, goal and issues of sustainable development", F8 "self-motivated", F14 "vision for a better future", F19 "identify direct and indirect consequences of any decision to people and eco-systems" and F21 "ability to specify the energy and environmental goals to associated supplier and contractors" which are grouped in a box.

Meanwhile, the "familiarity with building system manual (F13)" can lead to the achievement of "self-motivated" (F8), ability to "identify direct and indirect consequences of any decision to people and eco-systems" (F19), "ability to specify the energy and environmental goals to associated supplier and contractors" (F21) and "understand the bigger picture of significant aspects of sustainable development" (F22). In addition, the ability to "understand the design and

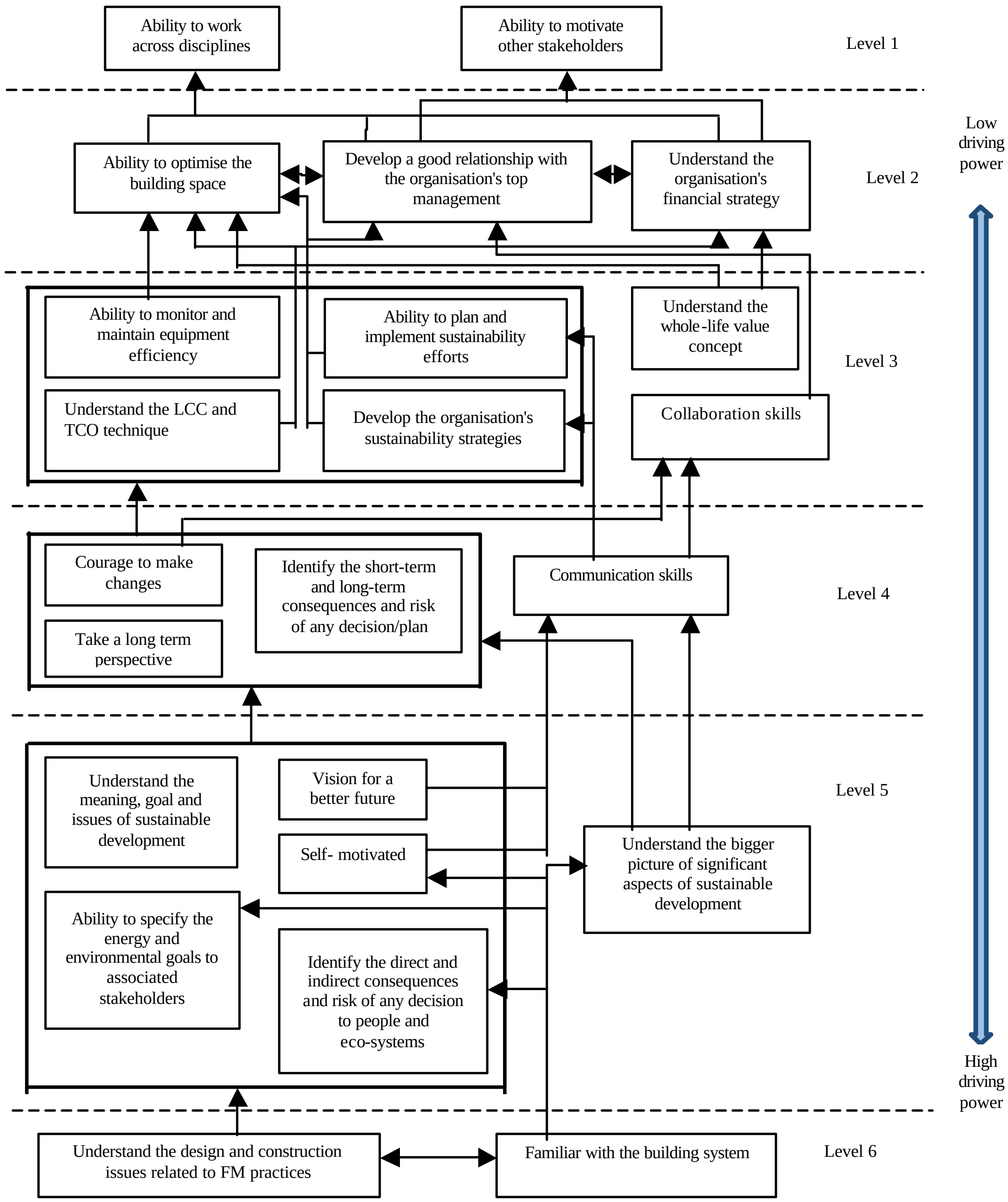

Fig. 1: Interpretive structural model of people capability factors

construction issues related to FM practices" (F12) and the "familiarity with the building system manual" (F13) are interdependent and help in achieving each other.

The ability to "understand the sustainable development concept and related issues" (F9), the "ability to specify energy and environmental goals" (F21), the ability to "identify the direct and indirect consequences of present decision" (F19), the ability to "understand the bigger picture of sustainable development" (F22), being b"self-motivated" (F8) and have a "vision for a better future" (F14) which are placed in Level 5 can collectively lead to achieving F23 "courage to make changes", F5 "take a long-term perspective" and F10 "identify the long-term and short-term consequences of any decision" which are placed in Level 4. In addition, having a "vision for a better future", being

Table 5: Levels of factors

Levels	Factors	Variables
I	3	Ability to work across discipline
	7	Ability to motivate other stakeholders
2	4	Develop a good relationship with the organization's top management
	6	Understand the organization's financial strategy
	11	Ability to optimise the building space
3	1	Understand the LCC and TCO technique
	2	Understand the whole life value concept
	15	Develop the organization's sustainability strategy
	17	Collaboration skills
	18	Ability to plan and implement sustainability efforts
	20	Ability to monitor and maintain equipment efficiency
4	5	Take a long term perspective
	10	Identify the short and long term consequences of any decision/plan
	16	Communication skills
	23	Courage to make changes
5	8	Self-motivated
	9	Understand the meaning, goal and issues of sustainable development
	14	Vision for a better future
	19	Identify direct and indirect consequences to people and ecosystem
	21	Ability to specify the energy and environmental goals to associate stakeholders
	22	Understand the bigger picture of significant aspect of sustainable development
6	12	Understand the design and construction issues related to FM practice
	13	Familiar with the building system

"self-motivated" and having the ability to "understand bigger picture of sustainable development" (F14, F8 and F22) will lead to the achievement of "communication skills" (F16).

The ability to "identify the short-term and long-term consequences of any current plan or decision" (F10), "take a long-term perspective" (F5) and the "courage to make changes" (F23) in Level 4 can help to achieve factors in Level 3, namely, the "ability to monitor and maintain equipment efficiency" (F20), the "ability to plan and implement sustainability efforts" (F18), the ability to "understand the LCC and TCO technique" (F1) and also the ability to "develop the organisation's sustainability strategy" (F15).

Furthermore, the "communication skills" ability can lead to the achievement of "collaboration skills" (F17), the "ability to plan and implement sustainability efforts" (F18) and the ability to "develop the organisation's sustainability strategies" (F15). In addition, collaboration skills can also be achieved by having the "courage to make changes" (F23).

In analysing the relationships between the factors in Level 3 and the factors in Level 2, it is observed that the "ability to optimise the building and equipment operation" (F11) which is placed in Level 2, can be achieved with the collective helped of factors in Level 3 such as the ability "to monitor and maintain equipment efficiency" (F20), the "ability to plan and implement sustainability effort" (F18), the ability to "develop the organisation's sustainability strategies" (F15), the ability "to understand the LCC and TCO technique" (F1) and the ability to "understand the whole-life value concept" (F2). In addition, the ability to "understand the LCC and TCO technique" (F1) and the ability to "understand the whole-life value concept" (F2) can collectively lead to the achievement of the ability to "understand the organisation's financial strategy" F6 in Level 2. Furthermore, the ability to "develop the organisation's sustainability strategy" (F15), the "ability to plan and implement sustainability efforts" (F18) and "collaboration skills" (F17) can lead to the ability to "develop good relationships with the organisation's top management" (F4) in Level 2.

It is interesting to note that the factors in Level 2, 3, 4 and 5 are interdependent and are able to help achieve each other in the same level of hierarchy.

The "ability to optimise the building and equipment operation" (F11), the ability to "develop a good relationship with the top management" (F4) and the ability to "understand the organisation's financial strategy" (F6) in Level 2 can lead to the achievement of the "ability to work across disciplines" (F3) which is placed in Level 1. Meanwhile, the "ability to motivate other stakeholders" (F7) in Level 1 can be achieved by "developing a good relationship with organisation's top management" and "understanding the organisation's financial strategy" (F4 and F6) in Level 2. The two factors in Level 1 are not dependent and cannot lead to achieve each other.

The driving power and the dependency of the factors were further analysed using Matrice d'Impacts Croises Multiplication Applique a un classemen or Cross Impact Matrix Multiplication Applied to Classification analysis, also known as MICMAC analysis (Faisal and Rahman, 2008; Mandal and Deshmukh, 1994). This step was conducted based on the final reachability matrix as shown in Table 4, where the dependence power of each factor is the sum of 1s in the corresponding column. Meanwhile, the driving power of each factor is attained by summing 1s in the relevant row. From this, the driving power and dependence diagram was constructed as shown in Fig. 2. The dependence and driving power can be assigned as the x-coordinate and y-coordinate of each factor, respectively. For example, it is observed from Table 4 that factor 8 has a driving power of 20 and a dependence of 18, so in Fig. 2, it is positioned in the square corresponding to driving power of 20 and dependence of 18.

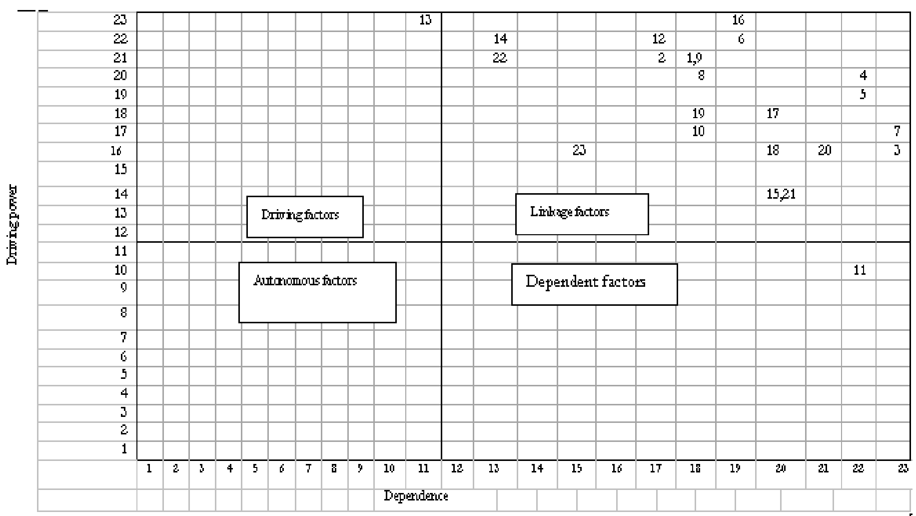

Fig. 2: MICMAC analysis (Driving power and dependence diagram)

The factors are classified into four clusters, namely: autonomous, dependent, linkage and driving based on their driving power and dependency. The first cluster consists of the "autonomous factors" that have weak driving power and weak dependence. These factors are normally disconnected from the system with limited linkages to other factors in the system (Faisal, 2010). The second cluster consists of those factors with weak driving power but strong dependence, also known as "dependent factor". The third cluster known as the "linkage factors" includes those factors with relatively strong driving power and strong dependence. These factors are unstable because any action on these factors will have an effect on other factors and also a feedback on themselves (Ahuja *et al.*, 2009). The fourth cluster includes the "driving factors" with robust driving power but weak dependence. It is observed that a variables with strong driving power falls into either "driving" or "linkage" categories.

RESULTS AND DISCUSSION

The driving power and dependence (Fig. 2) assists to classify various people capability factors that help to support the sustainability measures in FM practices. There are no factors in the autonomous cluster which mean that no variables can be disconnected from the whole system and attention must be given to all the identified factors. In the next cluster, includes those people capability factors with weak driving power but strong dependence, also known as "dependent factors". The factors in this cluster are primarily come at the top of the ISM model. One variable suits this feature in this research which is F11 "ability to optimise the building space".

The majority of the factors fell into the linkage factors category with relatively strong driving power and strong dependence. The factors categorised in this linkage cluster were primarily middle level factors where they were influenced by lower level factors and in turn will impact on other factors in the model. The factors includes in this cluster are including F16 "communication skills", F14 "vision for better future", F12 "understand the design and construction issues related to FM practice", F6 "understand the organization's financial strategy", F22 "understand the bigger picture of significant aspect of sustainable development", F2 "understand the whole-life value concept", F1 "understand the LCC and TCO technique", F9 "understand the meaning, goal and issues of SD", F8 "self-motivated", F4 "develop a good relationship with the organization top management", F5 "take a long term perspective", F19 "identify the direct and indirect consequences of any decision to people and eco-system", F17 "collaboration skills", F10 "identify the short and long term consequences of any decision", F7 "ability to motivate other stakeholders", F23 "courage to make changes", F18 "ability to plan and implement sustainability efforts", F20 "ability to monitor and maintain equipment efficiency", F3 "ability to work across discipline", F15 "develop the organization's sustainability strategies" and F21 "ability to specify the energy and environmental goals to associates stakeholders". The factors in this category, need proactive and special attention from the FM professionals since these factors have a high driving power and at the same time they are also dependent on the other factors.

The last cluster includes the driving factors having strong driving power but weak dependence. There is only one factor classified in this cluster which is F13 "Familiar with the building system". The factors in driving cluster primarily positioned at the bottom of the ISM-based model which indicate that this factor may be treated as the root factor in supporting the sustainable FM practices.

The developed ISM based model (Figure 1) provides a structure to the complex people capability factors that support sustainable FM practices. It shows that the factors related to interpersonal capability are primarily at the top of the hierarchy and strategic capability factors are primarily at the bottom of the hierarchy. Thus, FM practitioners are required to give more attention on strategically people capability factor enhancement in order to support the implementation of sustainability agenda in FM practices. However, the factors in the middle hierarchy consist of a mixture of factors categories in all four categories; strategic capability, anticipatory capability, interpersonal capability and system thinking capability. This means that all these factors are interrelated and cannot be achieved in isolation. This analysis provides a road map to FM practitioners or organizations to decide what factors should be prioritised from all of the critical people capability factors in their endeavour to promote the sustainability agenda in FM practices.

CONCLUSION

This study investigated the interrelationships between the critical people capability factors in supporting sustainable FM practices. Based on the findings from a pairwise comparison study with the FM industry experts, this research applied the ISM method to examine the factors' interrelationships through a systematic model. The ISM-based model developed and the subsequent MICMAC have identified the degree of interrelationship between the people capability factors. The hierarchical structure from ISM-based model developed suggest that factors in the strategic capability category were primarily positioned at the bottom of the hierarchy and regarded as the root of all other factors. Further, the MICMAC analysis also reinforces the same that the strategic related factors "familiar with the building system" have the high driving power and regarded as a fundamental factor. Thus, FM practitioners are required to give more attention on strategically people capability factor enhancement in order to support the implementation of sustainability agenda in FM practices. However, the factors in the middle hierarchy consist of a mixture of factors categories in all four categories; strategic capability, anticipatory capability, interpersonal capability and system thinking capability. This means that all these factors are interrelated and cannot be achieved in isolation. This is supported by the findings from MICMAC analysis where 21 factors were categorised in the linkage cluster which shows that they have a high driving power and at the same time they are also dependent on the other factors. Therefore, in order to support the implementation of sustainability in the FM practices, industry practitioners need to emphasis on increasing the capability in terms of strategy but at the same time they are also advised to give attention to other aspects of anticipatory, system thinking and interpersonal factors since they are linked and cannot be addressed separately. With reference to the interrelationships between the critical people capability factors and the proposed hierarchical structure, FM practitioners can better understand the people capability approach and implement appropriate steps as an effective solution to support the sustainable FM practices.

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