Validating a Critical Success Factor Instrument for Digital Facilities Management Implementation in Malaysia Using the Rasch Measurement Model

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ABSTRACT

Digital Facilities Management (DFM) has emerged as a strategic mechanism for improving asset performance, operational coordination, data visibility, and evidence-based decision-making in the built environment. Although previous studies have identified Critical Success Factors (CSFs) for DFM implementation, much of the literature remains focused on conceptual classification, systematic reviews, and theoretical development. Limited empirical research has examined whether DFM CSF indicators form a valid, reliable, and stable measurement instrument, particularly within the Malaysian Facilities Management context. This study addresses that gap by validating a CSF instrument for DFM implementation using the Rasch Measurement Model. A quantitative cross-sectional survey was conducted involving 427 Facilities Management professionals in Malaysia, representing clients, consultants, and contractors. The instrument comprised 41 indicators across eight CSF domains: Maintenance and Technology Integration; Organisational Leadership and Agility; Digital Transformation and Change Management; Sustainability and ESG; Compliance, Governance and Risk; Customer and Stakeholder Focus; Cost Leadership and Resource Optimisation; and Smart Asset and Space Management. Two measurement sets were analysed. Set B measured the perceived importance of each indicator, while Set C assessed implementation status. Rasch diagnostics examined rating scale functioning, item fit, item polarity, dimensionality, reliability, separation, Differential Item Functioning, person fit, and person–item targeting. The findings confirmed that both scales demonstrated measurement validity and reliability. All 41 items were retained. Most items showed productive fit, while several advanced or content-critical indicators displayed elevated or low fit values but retained positive polarity and strong theoretical relevance. Rating categories functioned logically, reliability and separation indices were strong, dimensionality supported dominant Rasch structures, and no significant DIF contrast was identified under the specified WINSTEPS classification. Methodologically, the study confirms the suitability of Rasch analysis for validating CSF instruments in organisational implementation research. Practically, the validated instrument supports DFM readiness assessment, maturity benchmarking, and evidence-based implementation planning within Malaysia's Facilities Management sector.

Keywords: Digital Facilities Management; Critical Success Factors; Rasch Measurement Model; Facilities Management; Implementation Readiness; Malaysia; Measurement Validation; Digital Transformation.

INTRODUCTION

Digital Facilities Management (DFM) represents a strategic evolution of Facilities Management (FM), where digital technologies, integrated data environments, and interconnected management systems are used to enhance facility operations and decision-making. In conventional FM practice, the emphasis has often been placed on maintenance coordination, service delivery, and asset support functions. However, Teicholz (2013) shows that the increasing use of digital asset information has shifted FM toward a more information-intensive discipline. Becerik-Gerber et al. (2012) similarly argue that BIM-enabled FM requires reliable data structures to support maintenance management, space management, and operational decision-making across the building lifecycle.

The emergence of technologies such as Building Information Modelling (BIM), the Internet of Things (IoT), Computerised Maintenance Management Systems (CMMS), Computer-Aided Facilities Management (CAFM), Digital Twins, and data analytics has expanded the role of FM from reactive operational coordination toward predictive, performance-oriented, and data-enabled management of built assets. Kensek (2014), for example, highlights the need for BIM-FM to support operational information requirements rather than remain confined to design documentation. Love et al. (2014) further emphasise that digital asset information creates value only when it is connected to benefits realisation and asset owner requirements. In the context of existing buildings, Volk et al. (2014) show that BIM adoption for FM requires careful attention to information quality, interoperability, and lifecycle usability rather than technology use alone.

Despite these developments, DFM implementation remains inconsistent across organisations. Ashworth and Tucker (2019) demonstrate that employer information requirements for BIM-FM depend heavily on organisational clarity, stakeholder coordination, and implementation discipline. Oluleye et al. (2021), in their study of BIM integration for FM operations, similarly found that implementation depends on both technical and organisational success factors. These studies indicate that digital technologies may be available, but their effective implementation depends on broader readiness conditions such as leadership commitment, workforce competency, system interoperability, data quality, change readiness, governance structure, and stakeholder alignment.

This implementation challenge is particularly relevant in Malaysia, where national digital transformation initiatives are progressing, but DFM readiness across FM organisations remains uneven. The issue is not merely whether organisations have access to digital systems. Rather, the more critical question is whether they possess the readiness conditions needed to implement, integrate, govern, and sustain digital FM practices. Naji et al. (2024), in their analysis of facility management preparedness for digital transformation, also emphasise that digital readiness involves organisational capability and preparedness, not simply the presence of technology.

Existing DFM studies have contributed significantly to the identification of Critical Success Factors (CSFs). Rockart (1979) introduced the CSF concept as a way of focusing managerial attention on the limited areas that must be performed satisfactorily for organisational success. Bullen and Rockart (1981) later clarified that CSFs help managers distinguish between many possible concerns and the few areas requiring continuous attention. In DFM implementation, this logic is valuable because organisations often face many simultaneous concerns, including technology integration, governance, training, cost control, stakeholder coordination, and regulatory compliance.

However, CSF identification alone is insufficient. A list of CSFs may be conceptually useful, but it is not necessarily suitable for diagnosis unless the instrument used to measure those CSFs is empirically validated. Bond and Fox (2015) argue that measurement quality must be established before researchers make substantive claims from survey responses. Boone et al. (2014) make a similar point in relation to Rasch analysis, explaining that response data should be examined to determine whether items function consistently within the intended construct. Without this validation step, CSF indicators may remain broad managerial statements rather than defensible diagnostic measures.

This study responds to that methodological gap by validating a CSF instrument for DFM implementation in Malaysia using the Rasch Measurement Model. Rasch (1960) introduced the model as a probabilistic approach to measurement, while Wright and Masters (1982) later extended its use for rating scale analysis. Linacre (2014) demonstrates how Rasch diagnostics can evaluate item fit, rating scale performance, reliability, separation, Differential Item Functioning, and person–item targeting. These capabilities make Rasch suitable for examining whether CSF indicators can validly measure DFM implementation readiness.

The central research question guiding this article is:

How valid and reliable is the Critical Success Factor instrument for measuring Digital Facilities Management implementation readiness in Malaysia when assessed using the Rasch Measurement Model?

This article makes three contributions. First, it provides empirical validation of a 41-item CSF instrument for DFM implementation in Malaysia. Second, it demonstrates the methodological value of Rasch analysis in organisational implementation and readiness studies. Third, it offers a validated diagnostic instrument that can support readiness assessment, benchmarking, and evidence-based planning for DFM implementation.

LITERATURE REVIEW

Digital Facilities Management Implementation

Facilities Management has evolved from a primarily operational support function into a strategic organisational discipline concerned with asset performance, service continuity, regulatory compliance, sustainability, and user experience. Teicholz (2013) positions BIM for facility managers as part of this wider shift because FM increasingly depends on structured information about assets, spaces, systems, and maintenance requirements. Pishdad-Bozorgi et al. (2018) also emphasise that FM-enabled BIM requires early planning and reliable information exchange if it is to support operations effectively.

DFM refers to the integration of digital systems, operational data, sensor-based technologies, and analytical tools into FM processes. For BIM-enabled FM, Becerik-Gerber et al. (2012) identify application areas such as maintenance management, space management, and asset information support. IoT technologies, as discussed by Minoli et al. (2017), provide the infrastructure for real-time building monitoring and energy optimisation. Digital Twin approaches extend this capability further, with Tao et al. (2018) explaining how digital twin-driven systems connect physical assets, data, and decision-making processes.

However, DFM should not be interpreted as the adoption of digital tools alone. Kensek (2014) notes that BIM for FM requires attention to future operational needs rather than modelling for its own sake. Love et al. (2014) similarly argue that digital information must be connected to owner value, benefits realisation, and asset management objectives. DFM implementation therefore depends on whether organisations can embed technology into workflows, governance arrangements, decision structures, and maintenance routines.

Many organisations acquire digital platforms without fully embedding them into FM practice. In such cases, digital adoption may remain fragmented and fail to generate expected operational benefits. Volk et al. (2014) show that BIM implementation for existing buildings is constrained by data availability, modelling effort, interoperability, and lifecycle usability. These constraints indicate that DFM implementation readiness must be understood as a multidimensional condition involving technological capability, organisational preparedness, and environmental alignment.

Critical Success Factors for DFM Implementation

Critical Success Factors are the limited areas that require sustained managerial attention for an initiative to be viable and effective. Rockart (1979) originally framed CSFs as the key information needs of executives, while Bullen and Rockart (1981) refined the concept into a practical managerial approach for identifying areas essential to success. In DFM implementation, CSFs represent the readiness conditions that organisations must address when planning, implementing, and sustaining digital transformation in FM.

Prior DFM-related studies have identified a wide range of CSFs. Ashworth and Tucker (2019), for instance, emphasise the importance of information requirements and stakeholder alignment in BIM-FM implementation. Oluleye et al. (2021), using fuzzy synthetic evaluation, highlight factors influencing BIM integration for FM operations. Silverio-Fernandez et al. (2019), in their study of smart devices in construction, show that successful implementation depends not only on technology readiness but also on organisational and human factors. These studies collectively suggest that CSFs in digital FM environments include leadership, training, technical infrastructure, interoperability, data quality, governance, stakeholder involvement, and change management.

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Nevertheless, CSF identification alone does not automatically produce a valid diagnostic instrument. A CSF framework becomes practically useful only when the indicators used to measure the factors are shown to be valid, reliable, and stable. Bond and Fox (2015) stress that valid measurement requires evidence that items work together to represent a coherent construct. Boone et al. (2014) similarly explain that Rasch analysis enables researchers to evaluate whether individual items behave productively within a measurement scale. Therefore, this study positions CSFs not merely as descriptive success labels, but as measurable implementation-readiness conditions requiring empirical validation.

Technology–Organisation–Environment Perspective

The Technology–Organisation–Environment (TOE) framework provides a suitable conceptual lens for structuring DFM implementation readiness. Tornatzky and Fleischer (1990) introduced TOE to explain how technological, organisational, and environmental contexts shape innovation adoption. Baker (2012) later described TOE as particularly useful for organisational-level technology adoption because it accommodates internal organisational readiness and external environmental pressures alongside technology characteristics.

In DFM implementation, the technological context includes digital infrastructure, interoperability, data integration, predictive capability, and system readiness. The organisational context includes leadership, governance, workforce competency, change readiness, stakeholder engagement, and resource allocation. The environmental context includes regulatory requirements, sustainability expectations, industry standards, client demands, and external policy pressures. TOE is therefore more suitable for DFM implementation than a purely individual-level adoption model.

Davis’s (1989) Technology Acceptance Model explains individual acceptance through perceived usefulness and perceived ease of use. These constructs are important, but DFM implementation often occurs at an organisational level where adoption may be mandated, coordinated through contracts, or shaped by asset owner requirements. TOE provides a broader structure because it accommodates organisational governance, technical infrastructure, and environmental compliance pressures.

In this study, the TOE framework is not employed as a causal or predictive model. Rather, it functions as an organising framework for structuring the CSF domains into technological, organisational, and environmental readiness conditions. The purpose of the study is therefore not to test directional relationships among TOE dimensions or to estimate their effects on implementation performance. Instead, the study uses TOE to provide conceptual coherence during instrument development, while the Rasch Measurement Model is applied to empirically validate whether the operationalised CSF indicators function as a stable, reliable, and invariant measurement structure. This distinction is important because the article focuses on measurement validation rather than causal modelling.

Rasch Measurement Model for Instrument Validation

The Rasch Measurement Model is a probabilistic measurement approach that evaluates the interaction between respondents and items along a latent continuum. Rasch (1960) established the model as a way of constructing measurement from response patterns, while Wright and Masters (1982) developed rating scale analysis for ordered response categories. Bond and Fox (2015) describe Rasch measurement as particularly valuable because it enables researchers to examine whether data fit the requirements of measurement rather than assuming that raw scores are automatically valid.

For CSF instrument validation, Rasch analysis provides several advantages. First, it evaluates whether rating categories function logically and progressively. Linacre (2014) explains that category functioning is important because disordered categories may indicate that respondents cannot distinguish between response options. Second, Rasch analysis examines item fit to determine whether each item contributes productively to the intended construct. Third, dimensionality analysis helps determine whether the items collectively form a dominant underlying construct. Boone et al. (2014) emphasise that these diagnostics are essential when survey instruments are used to support substantive interpretation.

Rasch analysis also provides reliability and separation statistics for both persons and items. High person separation indicates that the instrument can distinguish respondents with different levels of endorsement or maturity. High item separation indicates that the item hierarchy is stable. In addition, Differential Item Functioning enables the researcher to examine whether items operate consistently across respondent groups. These characteristics make Rasch analysis suitable for validating a DFM CSF instrument because the purpose of this study is not merely to rank CSFs descriptively, but to determine whether the instrument can reliably measure perceived importance and implementation status.

METHODOLOGY

Research Design

This study adopted a quantitative cross-sectional survey design. The design was selected because the primary aim of the study was to validate a structured measurement instrument and assess the psychometric quality of Critical Success Factor indicators for Digital Facilities Management implementation. The study does not examine causal relationships between CSFs and implementation performance. Instead, it focuses on whether the CSF indicators can validly and reliably measure DFM implementation readiness.

The overall methodological flow is illustrated in Figure 1. The process began with literature-based CSF identification, followed by TOE-based conceptual structuring, instrument development, survey data collection, dual measurement using Set B and Set C, Rasch measurement analysis, instrument validation, and readiness-based interpretation. This sequence shows how the study moved from conceptual development to empirical measurement validation.

Figure 1. Research methodological flow for validating the DFM Critical Success Factor instrument.

Respondents and Sampling

The survey involved 427 Facilities Management professionals in Malaysia. Respondents represented three key stakeholder groups: clients, consultants, and contractors. This respondent composition reflects the multi-stakeholder nature of DFM implementation, where strategic decisions, technical planning, operational execution, and service delivery are distributed across different actors.

The inclusion of these stakeholder groups strengthens the applicability of the instrument because DFM implementation readiness is not determined by a single organisation or role. Clients influence investment and strategic direction, consultants influence technical configuration and advisory decisions, while contractors and service providers influence operational implementation and system use. This multi-stakeholder orientation is consistent with Ashworth and Tucker's (2019) observation that BIM-FM implementation requires alignment between employer requirements, stakeholder expectations, and operational information needs.

Instrument Development

The instrument was developed based on literature-derived CSF domains and structured through the TOE framework. Following Tornatzky and Fleischer's (1990) logic, the instrument was designed to capture technological, organisational, and environmental readiness conditions. A total of 41 measurable indicators were operationalised under eight CSF domains. These domains represent the major readiness conditions associated with DFM implementation.

Table 1. CSF Domains Used in the Instrument

No.	CSF Domain	Main Readiness Focus
1	Maintenance and Technology Integration	Integration of digital tools into maintenance workflows
2	Organisational Leadership and Agility	Leadership commitment, agility, and strategic alignment
3	Digital Transformation and Change Management	Training, upskilling, stakeholder engagement, and change readiness
4	Sustainability and ESG	Energy efficiency, ESG alignment, and sustainability reporting
5	Compliance, Governance and Risk	Governance structures, standards, cybersecurity, and risk control
6	Customer and Stakeholder Focus	User needs, stakeholder engagement, and service responsiveness
7	Cost Leadership and Resource Optimisation	Investment planning, cost optimisation, and resource strategy
8	Smart Asset and Space Management	Asset intelligence, space optimisation, and digital asset visibility

Two measurement sets were analysed. Set B measured the perceived importance of each CSF indicator. Set C measured the status of implementation of the same indicators. This dual-measurement design enabled the instrument to capture both normative importance and practical implementation maturity. The distinction between importance and implementation is critical because an organisation may recognise a factor as important without having implemented it sufficiently.

Table 2. Construct Mapping and Validation Logic of the DFM CSF Instrument

Mapping Level	Pre-defined Structure	Number of Elements	Validation Evidence	Interpretation
Item to CSF indicator	Survey instrument	41 indicators	Item fit, item polarity, and rating scale functioning	Individual items were examined for measurement coherence and directional alignment

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Indicator to CSF domain	Literature-derived CSF framework	8 CSF domains	Dimensionality, reliability, and separation	Indicators were assessed as components of a broader DFM readiness construct
CSF domain to TOE context	TOE organising framework	3 conceptual contexts	Theoretical alignment and absence of DIF	TOE provided conceptual structuring without being treated as a causal model
Measurement set comparison	Set B and Set C	2 scales	Separate Rasch calibration for importance and implementation status	The instrument measured both normative importance and practical implementation maturity

This mapping verifies that the instrument was not treated as an unstructured list of factors. Instead, the 41 indicators were conceptually derived, organised under eight CSF domains, positioned through the TOE framework, and empirically validated through Rasch diagnostics. The validation logic therefore connects instrument operationalisation, theoretical structuring, and measurement evidence.

Rasch Validation Framework

The Rasch Measurement Model was applied to validate the DFM CSF instrument across two measurement sets: Set B, which measured the perceived importance of each CSF indicator, and Set C, which measured the implementation status of the same indicators. Figure 2 summarises the validation framework adopted in this study.

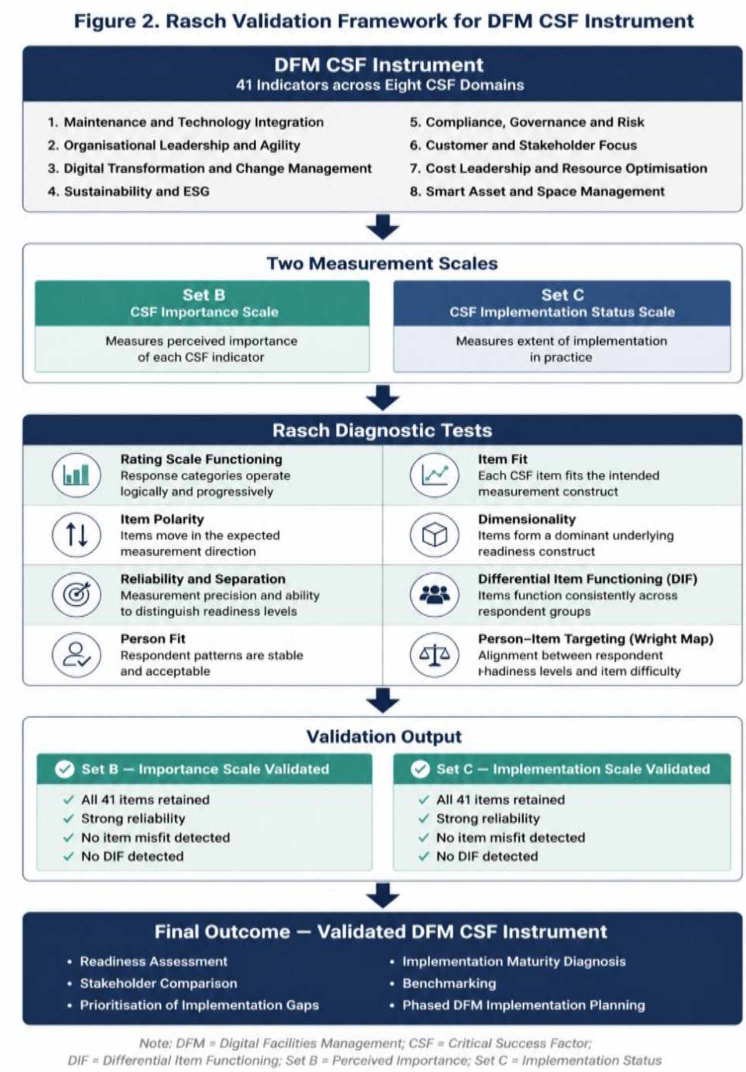

Figure 2. Rasch validation framework for the DFM Critical Success Factor instrument.

As shown in Figure 2, the validation process began with the 41-indicator DFM CSF instrument organised under eight CSF domains. The instrument was then assessed through two measurement scales representing perceived importance and implementation status. Both scales were subjected to Rasch diagnostics, including rating scale functioning, item fit, item polarity, dimensionality, reliability and separation, Differential Item Functioning, person fit, and person–item targeting. The purpose of these diagnostics was to determine whether the instrument functioned as a stable and defensible measurement structure for assessing DFM implementation readiness.

Following Linacre's (2014) analytical guidance, the Rasch analysis examined rating scale category functioning, item fit, item polarity, dimensionality, reliability, separation, Differential Item Functioning, person fit, and person–item targeting. Wright and Masters (1982) provide the basis for using ordered rating scale analysis, while Bond and Fox (2015) emphasise the importance of fit and dimensionality in establishing construct validity.

The acceptable range for Infit and Outfit Mean Square statistics was set between 0.7 and 1.3. Items within this range were considered productive for measurement. Reliability and separation indices were used to evaluate measurement precision, while Differential Item Functioning was used to examine whether items functioned consistently across respondent groups. Wright Map analysis was used to interpret the alignment between respondent measures and item locations.

RESULTS

Measurement Validation Overview

The Rasch validation process was conducted separately for Set B and Set C. Set B assessed perceived importance, while Set C assessed implementation status. This separation was necessary because perceived importance and implementation status represent different measurement conditions. Importance reflects respondent judgement regarding the relevance of CSFs, while implementation status reflects the extent to which those CSFs have been operationalised in practice.

The validation results confirmed that both scales met the required Rasch measurement conditions. The response categories functioned in an ordered manner, all 41 items were retained, most items demonstrated productive fit behaviour, and several advanced or content-critical indicators were retained with interpretive attention. Dimensionality results supported dominant measurement constructs, reliability and separation indices were high, and the DIF outputs showed no DIF contrast under the specified WINSTEPS classification.

Rating Scale Functioning

The rating scale analysis confirmed that the response categories for both Set B and Set C functioned logically. For Set B, responses were concentrated in the upper categories, indicating strong endorsement of the importance of the CSF indicators. A total of 45% of responses were recorded under "High Importance" and 30% under "Extremely Important," while only 1% were recorded under "Not Important at All." This pattern demonstrates that respondents generally perceived the CSF indicators as relevant to DFM implementation.

Although Set B responses were concentrated toward higher categories, the observed average measures increased progressively across the response categories. Linacre (2014) explains that this monotonic increase is important because it indicates that response categories are functioning in the intended order. In the present study, the ordered progression suggests that respondents were able to distinguish between increasing levels of importance.

For Set C, the response distribution was more dispersed. The largest proportion of responses was concentrated under "Partially Implemented," indicating that implementation maturity varied more widely than perceived importance. This pattern suggests that FM professionals generally agree on the importance of the CSFs, but actual implementation levels differ across organisations.

Table 3. Summary of Rating Scale Functioning

Measurement Set	Dominant Response Pattern	Rasch Interpretation	Substantive Meaning
Set B – Importance	Responses concentrated in “High Importance” and “Extremely Important”	Ordered category progression	Strong endorsement of CSF relevance
Set C – Implementation	Responses more dispersed, with concentration in partial implementation	Ordered category progression	Implementation maturity varies across organisations
Overall	Both scales show meaningful category progression	Suitable for Rasch calibration	Importance and implementation can be interpreted separately

Item Fit and Polarity

The item fit analysis for Set B indicated that the CSF importance scale was broadly productive for Rasch measurement. All 41 indicators were retained. Most items demonstrated productive fit behaviour, while several advanced or content-critical indicators, particularly BCSF1-05, BCSF1-03, BCSF1-04, BCSF6-30 and BCSF8-37, required interpretive attention due to elevated fit values or higher item measures. In Rasch analysis, Boone et al. (2014) note that item fit provides evidence of whether each item contributes meaningfully to the intended construct. In this study, these items were retained because they remained theoretically relevant and supported the interpretation of advanced DFM capability within the perceived importance construct.

For Set C, all 41 implementation status indicators were also retained. Most items demonstrated productive fit behaviour, while several implementation-intensive or conceptually distinctive indicators, including CSOIF1-03, CSOIF1-04, CSOIF5-25, CSOIF1-05 and CSOIF8-36, required interpretive attention due to elevated fit values. A small number of low-fit items also showed highly predictable response patterns but retained positive PTMEA values. The retention of the same item structure across both scales is important because it supports meaningful comparison between perceived importance and implementation status.

Item polarity was also examined through Point–Measure Correlation. The positive polarity of retained items confirmed that all indicators moved in the intended measurement direction. This means that higher endorsement of an item corresponded with a higher position on the DFM readiness continuum. The absence of negative polarity further supports the internal coherence of the instrument.

Table 4. Item Fit and Polarity Summary

Measurement Set	Number of Items Analysed	Fit Interpretation	Items Requiring Interpretive Attention	Polarity Result	Decision
Set B – Importance	41	Most items demonstrated productive Rasch fit behaviour. Several advanced or content-critical indicators showed elevated fit statistics but remained conceptually meaningful.	BCSF1-05, BCSF1-03, BCSF1-04, BCSF6-30, BCSF8-37	Positive item polarity reported for retained items	All 41 items retained
Set C – Implementation	41	Most items demonstrated productive Rasch fit behaviour. Several	CSOIF1-03, CSOIF1-04, CSOIF5-25,	Positive PTMEA values reported for all	All 41 items

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Measurement Set	Number of Items Analysed	Fit Interpretation	Items Requiring Interpretive Attention	Polarity Result	Decision
		implementation-intensive or conceptually distinctive indicators showed elevated or low fit values but remained meaningful within the construct.	CSOIF1-05, CSOIF8-36, CSOIF3-13, CSOIF7-35, CSOIF7-32	retained items	retained

The item fit evidence indicates that the CSF indicators were broadly coherent and statistically productive for measurement. Although several items required interpretive attention, their retention was supported by theoretical relevance, positive item polarity, and the overall stability of the Rasch measurement structure. This supports the use of the retained 41 indicators for measuring DFM implementation readiness.

Dimensionality

Dimensionality was assessed using Principal Component Analysis of residuals. For Set B, the Rasch dimension explained 57.8% of total raw variance. This exceeds the commonly accepted Rasch reference threshold of 40%, confirming the presence of a dominant measurement dimension for perceived importance.

For Set C, the Rasch dimension explained 60.7% of total raw variance, indicating a strong dominant measurement structure for implementation status. Bond and Fox (2015) explain that dimensionality evidence is necessary because a scale should measure a coherent underlying construct rather than a collection of unrelated item clusters. In this study, the dimensionality findings suggest that the items collectively measure a coherent DFM implementation readiness construct.

Table 5. Dimensionality Summary

Measurement Set	Variance Explained by Rasch Measures	Rasch Reference	Interpretation
Set B – Importance	57.8%	≥ 40%	Strong dominant measurement dimension
Set C – Implementation	60.7%	≥ 40%	Strong dominant measurement dimension

Although the instrument consists of eight CSF domains, the dimensionality findings indicate that the indicators function as interrelated components of a broader DFM implementation readiness construct. This supports the view that DFM readiness should be interpreted as an integrated organisational condition rather than a set of isolated factors.

Reliability and Separation

The reliability and separation statistics confirmed strong measurement precision for both Set B and Set C. For Set B, the person separation index was 4.29 with a reliability coefficient of 0.95, while the item separation index was 5.66 with an item reliability coefficient of 0.97.

For Set C, the person separation index was 4.97 with a reliability coefficient of 0.96, while the item separation index was 6.31 with an item reliability coefficient of 0.98. These results indicate that both scales demonstrated strong respondent differentiation and stable item hierarchies.

Table 6. Reliability and Separation Statistics

Measurement Set	Measure Type	Separation Index	Reliability Index	Interpretation
Set B – Importance	Person	4.29	0.95	Strong person separation and high person reliability based on the full respondent set
Set B – Importance	Item	5.66	0.97	Stable item hierarchy and excellent item reliability
Set C – Implementation	Person	4.97	0.96	Strong person separation and high person reliability based on the full respondent set
Set C – Implementation	Item	6.31	0.98	Highly stable item hierarchy and excellent item reliability

The reliability and separation statistics confirm strong measurement precision for both measurement sets. Set B demonstrated high person reliability and excellent item reliability for measuring perceived importance. Set C demonstrated similarly strong person reliability and even higher item separation, indicating that the implementation status scale was able to distinguish different levels of implementation maturity across respondents and maintain a stable hierarchy of implementation indicators.

Differential Item Functioning and Person Fit

Differential Item Functioning analysis was conducted to examine item stability under the specified WINSTEPS DIF classification. For both Set B and Set C, the DIF outputs showed no DIF contrast for all 41 items under the reported classification. However, because the outputs reported only one person class, the findings should be interpreted as evidence of item stability within the specified WINSTEPS classification rather than as a full multi-group stakeholder invariance test. Boone et al. (2014) describe DIF analysis as important because it helps determine whether items function differently across classification groups.

Table 7. Differential Item Functioning Summary

Measurement Set	Number of Items	DIF Result	Interpretation	Decision
Set B – Importance	**41**	**No DIF contrast observed under specified WINSTEPS classification**	**One person class reported; interpreted as item stability, not full multi-group invariance**	**All items retained**
Set C – Implementation	**41**	**No DIF contrast observed under specified WINSTEPS classification**	**One person class reported; interpreted as item stability, not full multi-group invariance**	**All items retained**

The DIF findings support item stability within the specified WINSTEPS classification. However, because only one person class was reported, the findings should not be interpreted as full stakeholder-group invariance. A separate DIF analysis using explicit stakeholder group classifications would be required to confirm whether the items function equivalently across clients, consultants, and contractors.

Person fit diagnostics also confirmed stable response behaviour. No respondents were removed due to unacceptable response patterns. This supports the reliability of the dataset and strengthens confidence in the resulting Rasch calibration.

Person–Item Targeting

Wright Map analysis was used to examine the alignment between respondent measures and item locations. Wright and Masters (1982) show that person–item maps are useful because they locate persons and items on the same measurement continuum. For Set B, respondents were generally positioned toward the higher end of the importance continuum, confirming strong overall endorsement of the CSF indicators. The distribution of items was sufficient to capture different levels of perceived importance.

For Set C, the respondent distribution was more varied, indicating differences in implementation maturity across organisations. This supports the interpretation that importance recognition is relatively high, while actual implementation remains uneven. The person–item targeting results therefore provide further evidence that the instrument can distinguish between normative importance and practical implementation maturity.

Overall Validation Synthesis

The overall validation evidence was interpreted cumulatively rather than through a single statistic. This is important because Rasch validation requires multiple forms of evidence to support measurement stability. In this study, rating scale functioning confirmed that respondents used the response categories meaningfully; item fit and polarity confirmed that the retained indicators were broadly productive for measurement, with several advanced or content-critical indicators requiring interpretive attention; dimensionality supported the presence of dominant measurement constructs; reliability and separation confirmed measurement precision; DIF analysis supported item stability within the specified WINSTEPS classification; and person fit indicated stable response behaviour. Taken together, these diagnostics provide a defensible basis for retaining the 41-item instrument.

Table 8. Overall Rasch Validation Summary

Diagnostic Component	Set B – Importance	Set C – Implementation	Overall Decision
Rating scale functioning	Ordered and functional five-category importance scale	Ordered and functional five-category implementation status scale	Acceptable
Item fit	All 41 items retained; most items productive, with several elevated/content-critical indicators retained based on theoretical relevance	All 41 items retained; most items productive, with several elevated or low-fit indicators retained based on theoretical relevance and positive polarity	Acceptable with interpretive attention
Item polarity	Positive item polarity reported for retained items	Positive PTMEA values reported for all retained items	Acceptable
Dimensionality	57.8% variance explained by Rasch measures	60.7% variance explained by Rasch measures	Strong dominant measurement dimension
Person reliability	0.95	0.96	High
Item reliability	0.97	0.98	Excellent
Person separation	4.29	4.97	Strong
Item separation	5.66	6.31	Excellent
Differential Item	No DIF contrast observed under the specified	No DIF contrast observed under the specified WINSTEPS	Item stability supported within the

Functioning	WINSTEPS classification; one person class reported	classification; one person class reported	specified classification; not interpreted as full multi-group invariance
Person fit	Respondent dataset retained for Rasch calibration	Respondent dataset retained for Rasch calibration	Stable dataset for instrument validation

Overall, the Rasch validation evidence supports the retention of the 41-item instrument across both measurement sets. The results demonstrate ordered rating scale functioning, strong reliability and separation, positive item polarity, dominant measurement dimensions, and stable item behaviour. However, the item fit and DIF findings should be interpreted carefully: several advanced or content-critical indicators required interpretive attention, and the DIF outputs support item stability within the specified WINSTEPS classification rather than full multi-group stakeholder invariance.

DISCUSSION

The findings demonstrate that the CSF instrument for DFM implementation functions as a valid and reliable measurement tool. This is important because previous DFM studies have often focused on identifying CSFs without sufficiently validating whether the indicators operate as a coherent measurement structure. While Ashworth and Tucker (2019) and Oluleye et al. (2021) provide valuable evidence on CSFs in BIM-FM and FM digital implementation contexts, the present study extends this stream of work by empirically validating a DFM CSF instrument using Rasch measurement.

The validation of Set B indicates that FM professionals strongly recognise the importance of the CSF domains. This suggests that the concept of DFM readiness is meaningful to Malaysian FM stakeholders. However, the more dispersed response pattern in Set C indicates that implementation maturity is uneven. The distinction between importance and implementation is critical because, as Love et al. (2014) observe in relation to BIM benefits realisation, recognising potential value is not the same as achieving operational implementation. In the present study, the results similarly show that awareness of CSF importance does not automatically translate into full implementation maturity.

The dimensionality findings provide an important theoretical implication. Although the instrument was organised into eight CSF domains, the Rasch results showed that the indicators formed a dominant underlying readiness construct. This supports the TOE-based framing of DFM implementation as a multidimensional but integrated phenomenon. Tornatzky and Fleischer’s (1990) TOE framework is useful because it allows technological, organisational, and environmental readiness conditions to be considered together. The present findings suggest that respondents experience these conditions as interconnected components of DFM implementation readiness rather than isolated factors.

The high reliability and separation indices strengthen the practical value of the instrument. Bond and Fox (2015) explain that strong reliability and separation indicate that a scale is capable of producing stable distinctions among persons and items. For FM organisations, this means the instrument can support readiness diagnosis, stakeholder comparison, and benchmarking. The higher separation values in Set C further suggest that implementation status provides a more discriminating view of organisational maturity than importance perception alone.

The DIF findings further support item stability under the specified WINSTEPS classification. The outputs for both Set B and Set C did not show DIF contrast for the 41 retained items. However, because only one person class was reported in the DIF output, the findings should not be overinterpreted as full multi-group stakeholder invariance. Instead, the result supports measurement stability within the reported classification and indicates that no DIF-based item removal was required.

From a methodological perspective, this study demonstrates the value of Rasch analysis in DFM implementation research. Conventional mean ranking and descriptive statistics can identify which indicators

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receive higher scores, but they do not confirm whether the instrument itself is valid, reliable, and invariant. Rasch analysis strengthens the empirical foundation by testing measurement quality before substantive interpretation. Linacre (2014) explains that Rasch diagnostics allow researchers to examine whether observed responses support the intended measurement structure.

The findings should also be interpreted within the methodological boundary of the study. The validated CSF instrument does not represent a causal model of DFM performance, nor does it estimate structural paths between TOE dimensions and implementation outcomes. Its purpose is to establish whether the CSF indicators can function as a valid measurement structure for readiness assessment. This distinction is important because measurement validation is a necessary step before causal modelling or predictive analysis can be meaningfully conducted. By confirming rating scale functioning, item fit, polarity, dimensionality, reliability, separation, DIF, and person fit, the present study establishes the measurement foundation upon which future explanatory or predictive models may be developed.

From a managerial perspective, the validated instrument provides a structured basis for assessing DFM readiness. Organisations can use the instrument to evaluate whether the necessary implementation conditions are present before investing further in digital systems. This shifts DFM planning from a technology-procurement approach toward a readiness-based implementation strategy. Such a shift is consistent with wider FM digitalisation literature, where technology adoption is repeatedly shown to require organisational alignment, data readiness, and operational integration rather than system acquisition alone.

Theoretical, Methodological and Practical Contributions

Theoretical Contribution

This study contributes theoretically by strengthening the conceptualisation of CSFs in DFM implementation. Rather than treating CSFs as general success labels, the study positions them as measurable implementation-readiness conditions. This interpretation aligns with Rockart's (1979) original managerial logic of focusing attention on critical areas, but extends it into the context of DFM readiness measurement. The findings also support the use of the TOE framework because DFM readiness emerges from the interaction of technological, organisational, and environmental conditions. However, TOE is used in this article as a conceptual organising structure rather than as a causal model.

Methodological Contribution

The study contributes methodologically by demonstrating the use of the Rasch Measurement Model for validating a CSF instrument in an organisational implementation context. Rasch (1960) provides the measurement foundation, while Wright and Masters (1982), Bond and Fox (2015), Boone et al. (2014), and Linacre (2014) provide the analytical basis for rating scale analysis, item fit, dimensionality, reliability, separation, DIF, and person–item targeting. By applying these diagnostics, the study provides a more rigorous measurement foundation than conventional descriptive CSF studies.

Practical Contribution

Practically, the validated instrument provides FM organisations with a diagnostic tool for assessing DFM implementation readiness. The instrument can support readiness audits, benchmarking, resource prioritisation, capability development, and phased implementation planning. It can also assist policymakers and industry bodies in identifying readiness gaps across the Malaysian FM sector. Rather than approaching DFM as a technology acquisition exercise, the instrument encourages organisations to assess whether foundational readiness conditions are present.

Limitations and Future Research

This study has several limitations. First, the data were collected through a cross-sectional survey, which captures respondent perceptions at one point in time. Future studies may apply the validated instrument longitudinally to examine how DFM readiness changes across different stages of implementation.

Second, although the sample included clients, consultants, and contractors, the study was conducted within the Malaysian FM context. Further validation in other national or regional settings would strengthen the generalisability of the instrument.

Third, this study validates the measurement structure of the CSF instrument but does not test causal relationships between CSFs and objective performance outcomes. Future research may examine how validated CSF readiness measures relate to indicators such as maintenance performance, asset reliability, energy efficiency, service responsiveness, or lifecycle cost optimisation.

Future studies may also extend the instrument across different facility types, including hospitals, universities, commercial buildings, public infrastructure, and industrial facilities. Sector-based comparison would help identify whether certain CSF domains are more demanding in highly regulated or asset-intensive environments. In addition, mixed-method research could be used to explain why certain CSFs are recognised as important but remain only partially implemented in practice.

CONCLUSION

This study validated a Critical Success Factor instrument for Digital Facilities Management implementation in Malaysia using the Rasch Measurement Model. Based on responses from 427 Facilities Management professionals, the study confirmed that the 41-item instrument demonstrated strong measurement validity and reliability across both perceived importance and implementation status scales.

The results showed that the rating scales functioned appropriately, all 41 items were retained, most items demonstrated productive Rasch fit behaviour, and several advanced or content-critical indicators were retained with interpretive attention. Item polarity was positive, dimensionality results confirmed dominant measurement structures, reliability and separation indices were strong, the DIF outputs showed no DIF contrast under the specified WINSTEPS classification, and person fit diagnostics supported stable response behaviour. These findings confirm that the instrument is suitable for assessing DFM implementation readiness.

The study advances DFM research by moving CSF analysis beyond descriptive listing toward empirical measurement validation. It also demonstrates the suitability of Rasch analysis for organisational implementation studies. From a practical perspective, the validated instrument can support readiness assessment, implementation benchmarking, resource allocation, and evidence-based DFM planning in Malaysia.

More broadly, the findings show that DFM implementation should not be treated merely as a technology procurement exercise. Successful implementation requires readiness conditions that are measurable, comparable, and strategically managed. The validated instrument developed in this study provides a foundation for such assessment and can support more structured, evidence-based and phased DFM implementation planning.

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