Rasch-Based Validation of Agreement and Usage Instruments for Integrated Project Quality Management Systems in Construction Projects

Mohd Farhan Mohd Fauzi [1], Mat Naim Abdullah@Asmoni [1], Ahmad Sha'rainon Md Shaarani [1], Naqiyatul Amirah Mohd Said [1], Muhammad Saufi Sumali [1]

[1] Department of Real Estate, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, UTM Johor Bahru, Malaysia

[2]Department of Quantity Surveying, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, UTM Johor Bahru

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ABSTRACT

Integrated Project Quality Management Systems (IPQMS) require robust measurement instruments to assess how project quality processes are recognised and practised by key construction stakeholders. Although quality management systems, project quality management and integrated management systems have been widely discussed in construction research, limited empirical attention has been given to validating instruments that measure IPQMS processes across stakeholder roles. This paper validates agreement and usage instruments for IPQMS processes using the Rasch Measurement Model. The study analysed six datasets representing three stakeholder groups: client representatives, consultants and contractors. A total of 67 IPQMS process items were examined, comprising 20 client representative items, 22 consultant items and 25 contractor items. Each item was measured across two dimensions: agreement and usage. Rasch analysis was conducted using WINSTEPS to evaluate rating scale functioning, reliability and separation indices, item and person fit, unidimensionality, differential item functioning and item hierarchy. The findings demonstrate that all six instruments showed ordered rating scale functioning, acceptable to excellent reliability, meaningful separation indices, productive item fit and essential unidimensionality. Several items with elevated fit statistics were retained due to their theoretical relevance and contribution to the IPQMS construct. The results confirm that the IPQMS agreement and usage instruments are psychometrically sound and suitable for subsequent critical process identification and structural model development. The study contributes to construction quality management research by demonstrating that role-specific IPQMS processes can be empirically validated through Rasch measurement, thereby providing a defensible measurement foundation for future critical process identification and logit-based structural positioning.

Keywords: Integrated Project Quality Management System; IPQMS; Rasch Measurement Model; construction quality management; instrument validation; project quality process; agreement; usage

INTRODUCTION

Construction projects are increasingly characterised by technical complexity, multiple stakeholder interfaces, contractual fragmentation and rising expectations for quality, safety, health, environmental performance and stakeholder accountability. In such an environment, quality management can no longer be viewed solely as a company-level certification exercise. Instead, quality management must be embedded at the project level, where client representatives, consultants and contractors interact to plan, implement, monitor and improve quality-related processes.

Quality Management Systems (QMS), particularly those aligned with ISO 9001, have provided construction organisations with formal mechanisms for documenting procedures, managing quality responsibilities and demonstrating compliance. Earlier construction quality studies emphasised conformance to specifications, defect prevention, customer satisfaction, process control and continuous improvement (Arditi & Gunaydin, 1997; Bubshait & Al-Atiq, 1999; Leong et al., 2014; Musayeva, 2024). However, the project-based nature of construction creates a persistent challenge. While organisations may be certified at the corporate level, quality outcomes are ultimately delivered at the project level through the interaction of multiple parties, contractual obligations and temporary project structures.

Previous research indicates that traditional quality management approaches in construction may result in fragmented documentation, duplicated procedures, weak coordination and limited integration across project participants (Bhutto, 2005; Simon et al., 2012; Dahlin & Isaksson, 2017). These weaknesses become more significant when construction projects must simultaneously address quality, safety, health, environmental and sustainability requirements. Integrated Management Systems and QSHE-based frameworks have therefore been proposed as mechanisms to reduce redundancy, improve process coordination and align multiple management requirements within a unified project system (Bernardo et al., 2009; Rofi'udin & Latief, 2018; de Nadae et al., 2021; Widjajakusuma et al., 2023).

The concept of Integrated Project Quality Management Systems (IPQMS) responds to this challenge by emphasising the integration of project quality planning, project quality implementation, project quality performance measurement and project quality improvement. Rather than allowing each project party to operate its own isolated quality plan, IPQMS seeks to align the activities of client representatives, consultants and contractors within a coordinated project quality framework. Such integration is particularly important because each stakeholder has different responsibilities, but their quality-related activities are mutually dependent.

Recent IPQMS research has shown that integrated process models have strong theoretical promise for improving process coordination, quality outcomes, risk reduction and stakeholder satisfaction. However, the literature also indicates that IPQMS research remains fragmented, geographically limited and still in need of stronger empirical validation (Rofi'udin & Latief, 2018; Widjajakusuma et al., 2023; Arman et al., 2025). Prior review evidence further suggests that many existing studies remain conceptual and that more rigorous empirical instruments are required to support future IPQMS implementation research.

Despite growing interest in integrated quality management, the measurement of IPQMS processes remains underdeveloped. Many construction quality studies rely on survey instruments developed from literature review or expert judgement, but fewer studies provide detailed psychometric evidence that the instruments are valid, reliable and suitable for further empirical modelling. Without instrument validation, subsequent findings on critical processes or structural models may be methodologically weak.

This paper addresses this gap by validating agreement and usage instruments for IPQMS processes using the Rasch Measurement Model. Rasch analysis is appropriate because it transforms ordinal Likert-type responses into interval-level logit measures and evaluates whether items and respondents function according to measurement expectations (Andrich, 1978; Wright & Masters, 1982; Bond & Fox, 2015; Boone et al., 2014). In the context of this study, Rasch analysis enables validation of whether IPQMS process items form coherent measurement instruments across stakeholder groups and measurement dimensions.

This study contributes to the IPQMS literature in three main ways. First, it provides empirical measurement validation for IPQMS instruments using the Rasch Measurement Model, addressing the methodological gap in existing IPQMS studies that are largely conceptual or framework oriented. Second, it validates both agreement and usage dimensions, allowing the study to distinguish between perceived importance and actual implementation of IPQMS processes. Third, it validates role-specific instruments across client representatives, consultants and contractors, reflecting the multi-stakeholder nature of project quality management in construction projects. By doing so, this study provides a validated measurement foundation for subsequent critical process identification and logit-based structural positioning of IPQMS processes.

The aim of this paper is to validate the IPQMS agreement and usage instruments across client representatives, consultants and contractors in construction projects.

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The specific objectives are:

1. To evaluate the rating scale functioning of the IPQMS agreement and usage instruments.
2. To assess person and item reliability and separation across stakeholder groups.
3. To examine item fit and person fit statistics for the IPQMS instruments.
4. To assess the unidimensionality and item invariance of the instruments.
5. To establish the suitability of the validated instruments for subsequent critical process identification and structural model development.

LITERATURE REVIEW

Quality Management Systems in Construction

Quality Management Systems provide a structured mechanism for defining quality policy, responsibilities, procedures, documentation, monitoring and improvement activities. In construction, QMS has historically evolved from inspection and quality control towards quality assurance, total quality management and continuous improvement. Early approaches largely focused on identifying defects after work completion, whereas later quality management approaches placed stronger emphasis on prevention, process control and customer satisfaction (Arditi & Gunaydin, 1997; Bubshait & Al-Atiq, 1999; Leong et al., 2014).

The adoption of ISO-based quality systems has further institutionalised quality management within construction organisations. ISO 9001 introduced a structured approach to documentation, responsibility allocation, management review, corrective action and continual improvement. However, construction is fundamentally project-based. Quality is not produced by one organisation alone but through the interaction of multiple stakeholders, including owners, consultants, contractors, subcontractors and suppliers. Therefore, the success of QMS in construction depends on the extent to which corporate-level systems can be translated into project-level processes (Leong et al., 2014; Musayeva, 2024).

Quality management in construction also differs from manufacturing because project outputs are unique, site-specific and shaped by contractual arrangements. Construction quality is closely associated with conformance to client requirements, specifications, drawings, statutory obligations, inspection results and handover expectations. Consequently, quality management at the project level requires integration between planning, implementation, performance monitoring and improvement processes.

Integrated Management Systems and QSHE Integration

The limitations of isolated management systems have encouraged the development of Integrated Management Systems (IMS). IMS approaches seek to combine quality, environmental, occupational health and safety, and other management system requirements into a coherent structure. In construction, such integration is important because project activities often involve overlapping quality, safety, environmental and stakeholder requirements (Bhutto, 2005; Bernardo et al., 2009; Simon et al., 2012).

Studies on IMS suggest that integration can reduce duplicated documentation, improve coordination, streamline audits, enhance communication and strengthen organisational learning (Zeng et al., 2007; Dahlin & Isaksson, 2017; de Nadae et al., 2021). However, integration is not merely a matter of combining documents or aligning procedures. Effective integration requires process-level coordination, shared responsibilities, cross-functional communication and performance monitoring.

In construction, QSHE integration has become increasingly relevant because quality, safety, health and environmental concerns are often interdependent. For example, poor design coordination may affect constructability, safety exposure, material waste and quality outcomes. Similarly, weak inspection and testing

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practices may create quality defects, safety hazards and contractual disputes. QSHE-based frameworks therefore emphasise integrated planning, risk-based thinking, process alignment and stakeholder involvement (Rofi'udin & Latief, 2018; Widjajakusuma et al., 2023; Arman et al., 2025).

Integrated Project Quality Management Systems

Integrated Project Quality Management Systems represent a project-level extension of QMS and IMS thinking. In this study, IPQMS is conceptualised through four process domains: Project Quality Planning, Project Quality Implementation, Project Quality Performance Measurement and Project Quality Improvement. These domains reflect the logic of process-based quality management and the Plan-Do-Check-Act cycle commonly associated with ISO-based systems.

Project Quality Planning establishes client requirements, project quality policy, quality objectives, project quality plans and quality-related documentation. Project Quality Implementation concerns the deployment of resources, personnel, facilities, training and execution of quality processes. Project Quality Performance Measurement involves inspection, testing, commissioning, reporting, certification, audit and evaluation activities. Project Quality Improvement concerns corrective actions, defect rectification, lessons learned and improvement initiatives.

IPQMS is particularly relevant in construction because different parties carry different but interdependent quality responsibilities. Client representatives usually initiate quality requirements, governance expectations and audit-related processes. Consultants translate requirements into design, supervision, inspection, testing and certification functions. Contractors implement physical works, submit project quality documents, coordinate subcontractors and carry out corrective actions. A valid IPQMS instrument must therefore reflect these role-specific responsibilities.

Previous review evidence suggests that IPQMS research has identified important processes such as integrated planning, process coordination, quality control and assurance, risk and safety integration, performance monitoring, environmental and sustainability processes, and continuous improvement. However, the same body of research also highlights the need for stronger empirical validation, more standardised measurement tools and broader application across construction contexts (Rofi'udin & Latief, 2018; Widjajakusuma et al., 2023; Chountalas & Lagodimos, 2025).

Agreement and Usage as Measurement Dimensions

The distinction between agreement and usage is important in IPQMS measurement. Agreement captures the extent to which respondents recognise the importance, relevance or appropriateness of an IPQMS process. Usage captures the extent to which the process is actually practised in construction project implementation.

This distinction is necessary because agreement does not always translate into usage. A stakeholder may agree that a process is important, such as training, audit planning or continuous improvement, but actual implementation may be constrained by resources, organisational maturity, contractual arrangements, project culture or governance mechanisms. Measuring agreement alone may therefore overestimate implementation readiness. Measuring usage alone may overlook processes that are recognised as important but not yet fully practised.

The combination of both dimensions provides a more complete basis for evaluating IPQMS. It enables the researcher to distinguish between perceived importance and actual implementation behaviour, which is particularly important in construction projects where formal procedures may exist but may not be consistently practised.

Need for Instrument Validation in IPQMS Research

Survey instruments are widely used in construction management research to measure perceptions, practices, barriers, success factors and implementation maturity. However, the validity of conclusions depends on the

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quality of the measurement instrument. Instruments developed without psychometric validation may contain misfitting items, poorly functioning rating scales, unreliable item ordering or multidimensional structures that weaken interpretation.

Instrument validation is particularly important for IPQMS because the construct involves multiple process domains and stakeholder groups. The same overall concept of project quality management may be expressed differently by client representatives, consultants and contractors. A role-based instrument must therefore be validated to ensure that its items contribute meaningfully to measurement within each group.

This paper therefore positions instrument validation as a necessary step between conceptual IPQMS development and substantive model interpretation. Before identifying critical processes or proposing a structural hierarchy, the measurement instruments must first demonstrate reliability, item fit, person fit, rating scale functioning, unidimensionality and item invariance.

Rasch Measurement Model

The Rasch Measurement Model offers a rigorous approach to instrument validation. Unlike classical test theory, which focuses mainly on total scores and reliability coefficients, Rasch analysis evaluates the interaction between persons and items on a common measurement scale. It estimates item difficulty and person ability in logits, enabling meaningful comparison between item hierarchy and respondent measures (Wright & Masters, 1982; Bond & Fox, 2015).

For rating scale instruments, Rasch analysis evaluates whether response categories function as intended. Ordered category functioning indicates that higher response categories represent higher levels of the measured construct. Reliability and separation indices indicate whether the instrument can distinguish different levels of respondents and item difficulty. Infit and Outfit Mean Square statistics identify items or persons that behave unexpectedly. Principal Component Analysis of residuals assesses whether a dominant latent construct is being measured. Differential Item Functioning evaluates whether items function consistently across relevant groups (Andrich, 1978; Linacre, 2002; Boone et al., 2014).

In this study, Rasch analysis is used not to test causal relationships but to validate the measurement structure of IPQMS agreement and usage instruments. This validation is necessary before the item hierarchy is interpreted for identifying critical IPQMS processes and before the findings are used for subsequent model development.

METHODOLOGY

Research Design

This study employed a quantitative instrument validation design using the Rasch Measurement Model. The purpose was to examine the psychometric adequacy of the IPQMS agreement and usage instruments prior to substantive interpretation. The analysis focused on six independent datasets derived from three stakeholder groups in construction projects.

Instrument Structure

The IPQMS instrument consisted of 67 process items distributed across three stakeholder groups: 20 items for client representatives, 22 items for consultants and 25 items for contractors. Each group-specific instrument was organised according to four IPQMS process domains: Project Quality Planning, Project Quality Implementation, Project Quality Performance Measurement and Project Quality Improvement.

Each item was measured using two five-point Likert-type scales. The agreement scale measured the extent to which respondents agreed with the relevance of each IPQMS process. The usage scale measured the extent to which the process was practised in project implementation.

Table 1 presents the structure of the IPQMS instrument by stakeholder group and measurement dimension.

Table 1: Structure of the IPQMS Instrument by Stakeholder Group

Stakeholder Group	Instrument Dimension	Dataset Code	Number of Items	Number of Respondents	Total Observations	Measurement Focus
Client Representative	Agreement	CRA	20	99	1,980	Perceived agreement toward IPQMS processes
Client Representative	Usage	CRU	20	99	1,980	Reported usage of IPQMS processes
Consultant	Agreement	CSA	22	99	2,178	Perceived agreement toward IPQMS processes
Consultant	Usage	CSU	22	99	2,178	Reported usage of IPQMS processes
Contractor	Agreement	COA	25	99	2,475	Perceived agreement toward IPQMS processes
Contractor	Usage	COU	25	99	2,475	Reported usage of IPQMS processes
Total	—	—	67	—	12,366	Agreement and usage validation across stakeholder groups

Note. CRA = Client Representative Agreement; CRU = Client Representative Usage; CSA = Consultant Agreement; CSU = Consultant Usage; COA = Contractor Agreement; COU = Contractor Usage; MNSQ = Mean Square; DIF = Differential Item Functioning.

The distribution of items according to IPQMS process domains is shown in Table 2.

Table 2: IPQMS Process Domains and Item Distribution

Stakeholder Group	Project Quality Planning	Project Quality Implementation	Project Quality Performance Measurement	Project Quality Improvement	Total Items
Client Representative	7	5	3	5	20
Consultant	5	4	7	6	22
Contractor	9	8	3	5	25
Total	21	17	13	16	67

Instrument Development and Content Validation

The IPQMS instrument was developed based on a combination of literature review, project quality management concepts, integrated management system principles and role-based quality responsibilities in construction projects. The initial identification of IPQMS processes was guided by four core process domains: Project Quality Planning, Project Quality Implementation, Project Quality Performance Measurement and Project Quality Improvement. These domains reflect the process-based logic of quality management and the need to align planning, implementation, monitoring and improvement activities at the project level.

The instrument was structured according to the roles of three key stakeholder groups in construction projects: client representatives, consultants and contractors. This role-based structure was adopted because each stakeholder group carries different quality-related responsibilities. Client representatives are primarily involved in defining client requirements, establishing project quality direction, audit planning, verification and governance oversight. Consultants are mainly responsible for design documentation, supervision, inspection, testing, reporting, certification and defect monitoring. Contractors are responsible for project quality submissions, resource planning, subcontractor coordination, physical implementation, corrective actions and handover activities. This role-based structure ensured that each item reflected the actual functional responsibility of the stakeholder group rather than treating IPQMS as a generic construct across all project participants.

The final instrument consisted of 67 IPQMS process items. These comprised 20 items for client representatives, 22 items for consultants and 25 items for contractors. The items were further organised according to the four IPQMS domains to ensure that the instrument covered the full project quality management cycle. Each item was measured using two dimensions: agreement and usage. The agreement dimension assessed the extent to which respondents recognised the relevance or importance of each IPQMS process, while the usage dimension assessed the extent to which the process was practised in actual project implementation.

Prior to Rasch analysis, the instrument was reviewed for content relevance, role appropriateness and conceptual alignment with IPQMS. The purpose of this review was to ensure that each item reflected a meaningful project quality process and was suitable for the stakeholder group to which it was assigned. The Rasch analysis was then used as the empirical validation stage to examine rating scale functioning, reliability, item fit, person fit, unidimensionality, item invariance and item hierarchy.

Respondents

The study involved three stakeholder groups: client representatives, consultants and contractors. Each stakeholder group consisted of 99 respondents. These groups were selected because they represent the key parties directly involved in planning, implementing, monitoring and improving project quality processes in construction projects.

Rasch Datasets

Six Rasch datasets were analysed independently:

1. Client Representative Agreement (CRA);
2. Client Representative Usage (CRU);
3. Consultant Agreement (CSA);
4. Consultant Usage (CSU);
5. Contractor Agreement (COA); and
6. Contractor Usage (COU).

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The datasets were analysed separately because each stakeholder group has different IPQMS responsibilities and item structures. Agreement and usage were also separated because they represent different measurement dimensions.

Data Analysis Procedure

Rasch analysis was conducted using WINSTEPS. The validation procedure examined rating scale functioning, category distribution, observed average measures, reliability and separation indices, item fit statistics, person fit statistics, Principal Component Analysis of residuals, Differential Item Functioning and item hierarchy.

Rating scale functioning was assessed by examining whether observed average measures increased monotonically across response categories. Person and item reliability were interpreted to determine measurement precision. Separation indices were used to assess the ability of the instruments to distinguish strata of respondents and item difficulty levels. Item fit was assessed using Infit and Outfit Mean Square values. Values between 0.5 and 1.5 were treated as productive for measurement, while elevated values were interpreted together with theoretical relevance. Unidimensionality was assessed using PCA of residuals. DIF analysis was used to examine item invariance within the analysed datasets.

To ensure consistency in interpreting the Rasch results, a set of validation criteria was applied across all six datasets. These criteria covered rating scale functioning, reliability and separation, item fit, person fit, unidimensionality and differential item functioning. Variance explained by measures above approximately 40% was treated as supportive evidence, while first contrast eigenvalue was interpreted together with substantive evidence of secondary dimension.Table 3 summarises the Rasch validation criteria used in this study.

Table 3: Rasch Validation Criteria Used in the Study

Validation Aspect	**Criterion / Indicator**	**Interpretation Used in This Study**
Rating scale functioning	Observed average measures should increase monotonically across categories	Monotonic increase indicates that respondents used the rating scale in the intended order
Category fit	Category Infit and Outfit MNSQ values are generally expected to fall within a productive measurement range	Elevated category fit was interpreted cautiously, particularly when caused by sparse category usage
Person reliability	Higher values indicate stronger consistency in differentiating respondent measures	Values above approximately 0.70 were considered acceptable for applied social science measurement
Item reliability	Higher values indicate stable and replicable item hierarchy	Values above approximately 0.70 were considered acceptable, while values above 0.80 indicated stronger item stability
Person separation	Higher separation indicates the instrument can distinguish different respondent strata	Higher separation values were interpreted as stronger differentiation of agreement or usage levels
Item separation	Higher separation indicates clearer differentiation among item difficulty levels	Higher item separation supported the stability of item hierarchy

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Item fit	Infit and Outfit MNSQ values around 1.00 indicate productive measurement; values between 0.5 and 1.5 were treated as generally acceptable	Items outside the preferred range were reviewed together with theoretical relevance and overall model stability
Person fit	High person misfit indicates inconsistent response patterns	Misfitting respondents were retained where the overall model remained stable and the proportion of misfit was within acceptable applied research tolerance
Unidimensionality	PCA of residuals should support a dominant measured construct; variance explained by measures and first contrast eigenvalue were examined	Instruments were considered essentially unidimensional when the Rasch dimension dominated and no meaningful secondary dimension was detected
Differential Item Functioning	No significant DIF indicates item invariance within the analysed dataset	Absence of significant DIF supported item fairness and stability
Item hierarchy	Logit ordering should produce meaningful differentiation among IPQMS processes	Stable item hierarchy supported subsequent critical process identification and structural positioning

RESULTS

Overall Rasch Validation

The Rasch analysis indicated that all six IPQMS instruments demonstrated acceptable measurement properties. The six datasets comprised Client Representative Agreement (CRA), Client Representative Usage (CRU), Consultant Agreement (CSA), Consultant Usage (CSU), Contractor Agreement (COA), and Contractor Usage (COU). Each dataset was analysed independently using the Rasch Rating Scale Model to evaluate rating scale functioning, reliability and separation, item and person fit, unidimensionality, differential item functioning, and item hierarchy.

Overall, the findings indicate that the IPQMS agreement and usage instruments are psychometrically sound. The observed average measures increased monotonically across response categories in all datasets, indicating ordered scale functioning. Person reliability ranged from acceptable to excellent, while item reliability ranged from adequate to excellent. Most items demonstrated productive fit to the Rasch model. Several elevated or misfitting items were identified, particularly in relation to training, Project Quality Plan development, personnel deployment, and improvement activities. However, these items were retained because they were theoretically central to the IPQMS construct and did not compromise the overall measurement structure.

Rating Scale Functioning

All six datasets demonstrated ordered rating scale functioning based on monotonic increases in observed average measures across the five response categories. This indicates that respondents used the rating scales in the intended direction, with higher categories representing higher levels of agreement or usage.

For CRA, the observed average measures increased from -10.50 in Category 1 to 48.20 in Category 5. Although Category 1 demonstrated elevated category fit statistics, it was used by only 0.35% of responses. This suggests that the elevated category fit was likely due to sparse category usage rather than a major threat to scale validity. For CRU, the observed average measures increased from -16.48 to 19.26, and all category fit values fell within acceptable Rasch limits.

For CSA, the observed average measures increased from 2.22 to 48.34, confirming ordered rating scale functioning. For CSU, the observed averages increased from -6.20 to 33.79. For COA, the observed average measures increased from -37.86 to 54.79, while for COU they increased from -12.64 to 31.09. These results provide consistent evidence that the five-point rating scales functioned adequately across stakeholder groups and across both agreement and usage dimensions.

A general difference was observed between agreement and usage instruments. Agreement datasets showed stronger concentration in Categories 4 and 5, indicating high endorsement of IPQMS processes. Usage datasets showed wider distribution across Categories 3 to 5, indicating more variation in actual implementation behaviour.

Reliability and Separation

The reliability and separation results are summarised in Table 4.

Table 4: Summary of Rasch Reliability and Separation Indices

Dataset	Person Reliability	Person Separation	Item Reliability	Item Separation	Measurement Interpretation
CRA	0.88	2.68	0.80–0.83	2.02–2.18	Strong person reliability and adequate item stability
CRU	0.76	1.79	0.99	9.95–10.37	Acceptable person reliability and very strong item hierarchy stability
CSA	0.87	2.57	0.85–0.86	2.35–2.49	Strong reliability with stable consultant agreement hierarchy
CSU	0.93	3.74	0.91–0.92	3.19–3.38	Excellent person and item reliability
COA	0.91	3.13	0.85–0.86	2.34–2.47	Strong reliability with stable contractor agreement hierarchy
COU	0.93	3.64	0.91–0.92	3.11–3.30	Excellent reliability and strong hierarchy consistency

Note. CRA = Client Representative Agreement; CRU = Client Representative Usage; CSA = Consultant Agreement; CSU = Consultant Usage; COA = Contractor Agreement; COU = Contractor Usage; MNSQ = Mean Square; DIF = Differential Item Functioning.

As shown in Table 4, person reliability ranged from 0.76 to 0.93. The lowest person reliability was recorded in CRU, but the value remained acceptable for applied measurement. The strongest person reliability values were recorded in CSU and COU, both at 0.93. This indicates that the consultant and contractor usage instruments were able to distinguish more clearly between different levels of reported usage behaviour.

Item reliability ranged from adequate to excellent. CRU recorded very strong item reliability at 0.99, indicating a highly stable item hierarchy. CSU and COU also showed strong item reliability values ranging from 0.91 to 0.92. The reliability findings confirm that the instruments can distinguish different levels of respondent agreement and usage while producing stable item ordering.

Item Fit, Unidimensionality and Differential Item Functioning

The item fit, unidimensionality and DIF findings are presented in Table 5.

Table 5: Summary of Rasch Fit, Unidimensionality and DIF Results

Dataset	Mean Infit MNSQ	Mean Outfit MNSQ	Elevated / Misfitting Items	Unidimensionality Evidence	DIF Result	Overall Validation Status
CRA	1.00	0.94	Recommend capable consultant and contractor; Deploy construction personnel; Conduct audit and prepare report; Prepare audit plan	Variance explained by measures >40%; first contrast <2.0; no evidence of secondary dimension	No significant DIF	Accepted with retained theoretically relevant elevated items
CRU	0.98	0.99	Identify client requirements; Organise appropriate trainings were borderline but within tolerance	Variance explained by measures ≈50%; first contrast ≈2.0–2.5	No item bias detected	Accepted
CSA	1.01	0.90	Organise / participate in trainings	Variance explained by measures >40%; first contrast <2.0; no evidence of secondary dimension	No significant DIF	Accepted with retained training item
CSU	0.99	0.96	Develop and submit PQP; Prepare final account	Variance explained by measures >40%; first contrast <3.0; no evidence of secondary dimension	No significant DIF	Accepted
COA	1.01	0.91	Organise / participate in trainings	Variance explained by measures 58%; first contrast 2.6; no evidence of secondary dimension	No significant DIF	Accepted with caution on training item

COU	0.99	0.99	Develop and submit PQP; Carry out improvement activities	Variance explained by measures >40%; first contrast <2.0; no evidence of secondary dimension	No significant DIF	Accepted

Note. CRA = Client Representative Agreement; CRU = Client Representative Usage; CSA = Consultant Agreement; CSU = Consultant Usage; COA = Contractor Agreement; COU = Contractor Usage; MNSQ = Mean Square; DIF = Differential Item Functioning.

The mean Infit and Outfit values across the six datasets were close to 1.00, indicating overall conformity to Rasch model expectations. The CRA dataset recorded several elevated underfit items, including recommending capable consultants and contractors, deploying construction personnel, conducting audit and preparing reports, and preparing audit plans. These items were retained because they remained theoretically relevant to IPQMS governance and project quality control.

In CSA, the item “Organise / participate in trainings” showed elevated fit statistics. The same training-related item also showed stronger misfit in COA. However, in the COA dataset, 24 out of 25 items were within acceptable Rasch fit limits, and only the training item demonstrated clear misfit. This item was retained because training is conceptually important to project quality implementation, organisational capacity and continuous improvement. In COU, the elevated items were “Develop and submit PQP” and “Carry out improvement activities”, both of which were retained due to theoretical importance.

Unidimensionality was supported across all datasets. CRA, CSA, CSU, COA and COU reported no evidence of a meaningful secondary dimension. COA recorded a first contrast eigenvalue of 2.6, which was slightly above the stricter 2.0 guideline but still interpreted as acceptable because the variance explained by measures was 58% and no secondary dimension was identified. DIF results also indicated no significant item bias within the analysed datasets.

Person Fit

Person fit analysis indicated that a small proportion of respondents demonstrated misfit behaviour across the datasets. The proportion of misfitting respondents generally remained within acceptable tolerance for field-based social science research. CRA recorded approximately 5–7% moderate misfit, while CRU recorded approximately 6% misfit. CSA reported less than 6% substantial misfit, CSU recorded approximately 7–8% moderate misfit, and both COA and COU reported approximately 5–7% misfit.

Some extreme scorers were observed, particularly in the agreement datasets. For example, agreement instruments showed a tendency for respondents to provide consistently high ratings. However, reliability statistics, item hierarchy and overall model stability were not compromised. Therefore, no respondent removal was required.

Rasch Item Hierarchy as Preliminary Evidence

Although the main purpose of this paper is instrument validation, the Rasch item hierarchy provides preliminary evidence of process positioning. Across datasets, training, audit-related activities, improvement activities, infrastructure provision and Project Quality Plan development tended to appear at higher logit positions.

These processes are more demanding in terms of agreement or usage. In contrast, inspection, testing, documentation, relationship maintenance and routine coordination tended to appear at lower logit positions.

Table 6 summarises the highest and lowest logit processes across the six datasets.

Table 6: Highest and Lowest Logit IPQMS Processes Across Rasch Datasets

Dataset	Highest Logit Processes / Most Demanding Items	Lowest Logit Processes / Most Easily Endorsed or Used Items	Interpretation
CRA	Prepare audit plan; Review design and contract documents; Organise appropriate trainings; Conduct audit and prepare report; Lead improvement activities	Identify client requirements; Develop PQP; Verify inspection and commissioning; Verify reports and certificates; Set up and maintain project policy	Governance, audit and oversight-related processes are more demanding for client representatives, while foundational planning and verification processes are more routinely agreed upon
CRU	Prepare audit plan; Develop Project Quality Plan; Lead improvement activities; Conduct audit and prepare report; Organise appropriate trainings	Identify client requirements; Review design and contract documents; Verify reports and certificates; Maintain relationship; Verify materials	Audit, PQP and improvement activities are less consistently used compared with routine verification, documentation and relationship-based processes
CSA	Organise / participate in trainings; Approve project reports; Deploy supervision personnel; Identify client requirements	Prepare design and contract documents; Approve testing and commissioning; Conduct inspection and testing	Strategic supervision, reporting and training processes are more demanding, while technical inspection and documentation processes are more routinely accepted
CSU	Organise / participate in trainings; Carry out improvement activities; Develop and submit PQP; Ensure facilities and infrastructure; Cooperate during audit	Conduct inspection and testing; Issue defects list and monitor repairs; Approve testing and commissioning; Prepare design and contract documents	Capacity-building, improvement, PQP and audit-related processes are less frequently used than routine technical compliance tasks
COA	Organise / participate in trainings; Provide facilities / infrastructure; Award trades to appropriate subcontractors; Purchase materials, plant and equipment at required time; Initiate inspection and testing	Perform physical and documentation handover; Set up and maintain project policy; Review contract document; Identify client requirements; Maintain good relationship	Resource-intensive and coordination-based processes are more demanding for contractors, while relational, contractual and planning processes are widely agreed upon
COU	Organise / participate in trainings; Carry out improvement activities; Provide facilities / infrastructure; Award trades to appropriate subcontractors; Cooperate during audit	Perform physical and documentation handover; Participate in site meetings; Prepare construction programme; Set up project policy; Maintain good relationship with parties	Training, improvement, infrastructure and audit-related activities are less consistently used, while routine coordination and relationship processes are embedded in contractor practice

Note. CRA = Client Representative Agreement; CRU = Client Representative Usage; CSA = Consultant Agreement; CSU = Consultant Usage; COA = Contractor Agreement; COU = Contractor Usage; MNSQ = Mean Square; DIF = Differential Item Functioning.

Table 6 confirms that the validated instruments can differentiate between more demanding and more routinely embedded IPQMS processes. However, the detailed structural interpretation of these logit hierarchies is beyond the scope of this paper and should be addressed in a separate paper on empirical structural positioning.

Overall Validation Summary

The overall validation conclusion is summarised in Table 7.

Table 7: Overall Rasch Validation Conclusion for the IPQMS Instruments

Validation Criterion	Evidence Across Six Datasets	Conclusion
Rating scale functioning	All datasets demonstrated monotonic increase in observed average measures across response categories. CRA showed elevated fit for the lowest category, but this category was rarely used.	The five-point rating scales functioned adequately overall. Sparse lower-category usage should be acknowledged for agreement instruments.
Person reliability	Person reliability ranged from 0.76 to 0.93.	Instruments can distinguish different levels of respondent agreement or usage, with strongest differentiation in CSU and COU.
Item reliability	Item reliability ranged from 0.80–0.83 to 0.99.	Item hierarchies are generally stable and replicable, particularly for CRU, CSU and COU.
Item fit	Most items showed productive fit. Elevated items were found in CRA, CSA, CSU, COA and COU. The strongest misfit occurred for the training item in COA.	Items generally contributed productively to measurement. Elevated items were retained due to theoretical importance and overall model stability.
Person fit	Misfitting respondents generally ranged between approximately 5% and 8%.	Person misfit remained within acceptable applied research tolerance, and no respondent removal was required.
Unidimensionality	PCA of residuals supported essential unidimensionality across datasets. COA first contrast was 2.6 but interpreted as acceptable with 58% variance explained and no secondary dimension.	Each instrument measured a dominant latent construct.
DIF	No significant item bias was detected within the analysed datasets.	Items functioned consistently within each dataset.
Overall status	All six datasets met Rasch measurement requirements with some retained theoretically relevant elevated items.	The IPQMS instruments are psychometrically sound for further empirical analysis.

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Taken together, the findings confirm that the IPQMS agreement and usage instruments satisfy Rasch measurement requirements and are suitable for subsequent empirical analysis, including critical process identification and logit-based structural positioning.

DISCUSSION

Psychometric Adequacy of the IPQMS Instruments

The results confirm that the IPQMS instruments achieved acceptable psychometric quality across all six datasets. The rating scale analysis demonstrated monotonic increases in observed average measures, indicating that respondents used the five-point scales in the intended order. This provides important evidence that the agreement and usage instruments were understood by respondents and functioned as meaningful ordered scales.

The reliability and separation results further demonstrate that the instruments can distinguish different levels of respondent agreement and usage. The stronger person separation values in CSU and COU suggest that usage instruments for consultants and contractors captured greater variation in implementation behaviour. This is reasonable because actual usage is likely to vary more than agreement, especially in construction projects where implementation depends on project context, resource availability, contract arrangements and organisational maturity.

Item reliability was adequate to excellent across the datasets. This confirms that the item hierarchies are sufficiently stable to support further interpretation. This is particularly important for IPQMS research because the next stage of analysis depends on identifying which processes are more demanding and which are more routinely embedded.

Rating Scale Behaviour and Sparse Lower Categories

The agreement instruments, particularly CRA, CSA and COA, showed response concentration in Categories 4 and 5. This indicates strong endorsement of IPQMS processes among respondents. However, it also created sparse lower-category usage. For example, in CRA, Category 1 was used by only 0.35% of responses and showed elevated category fit statistics. This pattern should not be interpreted as a failure of the overall scale. Instead, it reflects a sparse-category effect caused by very low use of the lowest response option.

The usage instruments showed broader distribution across Categories 3 to 5. This suggests that usage items captured more variation in actual project practice. The difference between agreement and usage strengthens the study because it shows that respondents may generally agree with IPQMS processes, while actual implementation varies according to role, project practice and organisational capacity.

Agreement and Usage as Complementary Measures

The findings support the value of measuring both agreement and usage. Agreement instruments indicate whether stakeholders recognise the relevance of IPQMS processes. Usage instruments indicate whether these processes are actually practised in construction project implementation.

This distinction is important because agreement does not automatically translate into usage. Processes such as training, audit planning, Project Quality Plan development and improvement activities may be recognised as important but may require stronger governance, resources, technical capability or coordination to be consistently implemented. The dual measurement of agreement and usage therefore provides a more complete understanding of IPQMS implementation readiness.

Role-Based Measurement Across Stakeholder Groups

The validation of separate instruments for client representatives, consultants and contractors reflects the role-based nature of construction project quality management. A single generic instrument may not adequately capture differences in stakeholder responsibilities. Client representatives are more directly involved in

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governance, requirement definition, audit planning and verification. Consultants are more involved in design, supervision, inspection, testing, reporting and certification. Contractors are responsible for planning submissions, resource management, subcontractor coordination, physical works implementation, corrective actions and handover.

The Rasch results show that these role-specific instruments can be measured reliably. This supports the methodological position that IPQMS should be assessed through stakeholder-sensitive measurement rather than through a single undifferentiated scale.

Interpretation of Elevated and Misfitting Items

Several elevated items were identified across the datasets. In CRA, elevated items included recommending capable consultants and contractors, deploying construction personnel, conducting audit and preparing reports, and preparing audit plans. These processes are governance-oriented and may be interpreted differently by respondents depending on project authority, role expectation and organisational practice.

In CSA and COA, the training-related item showed elevated fit statistics. The COA training item demonstrated the strongest misfit among the six datasets. However, this item was retained because it represents a theoretically important IPQMS process. Training is central to quality implementation, capability development and continuous improvement. Its misfit may indicate variation in how contractors perceive training: some may see it as integral to quality management, while others may view it as a supplementary or compliance-driven activity.

In CSU and COU, elevated items were related to PQP development, final account preparation and improvement activities. These items may reflect processes that are more dependent on project maturity, contractual requirements and organisational systems. Rather than weakening the instrument, these elevated items highlight areas of implementation complexity within IPQMS.

Theoretical and Methodological Contribution

This study contributes to construction quality management literature by providing empirical measurement validation for IPQMS instruments. Previous research has discussed quality management systems, integrated management systems, QSHE integration and project quality processes, but instrument validation across multiple construction stakeholder groups remains limited.

By applying the Rasch Measurement Model, this study strengthens the methodological foundation of IPQMS research. It demonstrates that agreement and usage of IPQMS processes can be measured reliably across client representatives, consultants and contractors. This provides a validated basis for further studies on critical process identification, stakeholder comparison and structural model development.

The study also extends IPQMS research by showing that role-based project quality processes can be validated through a common measurement logic while still respecting stakeholder-specific responsibilities. This is important because construction project quality is delivered through coordinated contributions across the project team rather than through a single actor.

Practical Implications

The validated IPQMS instruments can support construction organisations in assessing project quality practices across stakeholder roles. Client organisations can use the instrument to assess whether quality requirements, audit planning and verification processes are properly embedded. Consultants can use it to evaluate supervision, inspection, reporting and certification practices. Contractors can use it to assess planning submissions, resource management, subcontractor coordination, corrective actions and improvement activities.

The agreement–usage distinction also provides diagnostic value. Where agreement is high, but usage is lower, the issue may not be awareness but implementation capability. Such gaps may indicate the need for stronger governance, clearer responsibilities, better training, improved documentation systems or more effective monitoring mechanisms.

Implications for Subsequent Structural Modelling

The validation findings provide an important foundation for subsequent structural modelling of IPQMS processes. Since the instruments demonstrated ordered rating scale functioning, acceptable to excellent reliability, productive item fit and essential unidimensionality, the resulting item hierarchies can be interpreted with greater confidence. This is important because structural positioning based on Rasch logit hierarchy should only be developed after the measurement instruments have been shown to be psychometrically sound.

The stable item reliability values indicate that the ordering of IPQMS processes is sufficiently replicable to support further analysis. This allows subsequent research to examine which processes occupy higher logit positions and therefore represent more demanding or less consistently implemented processes. Similarly, lower logit items may indicate processes that are more routinely endorsed or embedded in project practice. Such logit-based differentiation can be used to support the development of a structural hierarchy of IPQMS processes.

However, the present paper does not attempt to develop the full structural model. Its purpose is limited to validating the measurement instruments. The Rasch item hierarchy presented in this paper should therefore be interpreted as preliminary evidence rather than a complete structural model. Future research can build on this validated measurement foundation by examining the empirical structural positioning of IPQMS processes across strategic, managerial and operational layers.

LIMITATIONS AND FUTURE RESEARCH

This paper focuses specifically on measurement validation and therefore does not provide a full substantive interpretation of the IPQMS process hierarchy. The study is also based on role-specific stakeholder instruments and separate Rasch datasets. Future studies may extend the analysis by comparing stakeholder groups more directly, examining cross-project differences, investigating implementation maturity and developing an empirical structural hierarchy of IPQMS processes based on logit positioning.

Future research should also examine how validated IPQMS instruments can be applied in different project types, contractual arrangements and organisational contexts. Such studies would strengthen the generalisability of IPQMS measurement and support the development of more practical implementation models for construction projects.

CONCLUSION

This paper validated the agreement and usage instruments for Integrated Project Quality Management Systems in construction projects using the Rasch Measurement Model. Six independent datasets were analysed, covering client representatives, consultants and contractors across agreement and usage dimensions.

The findings show that all six instruments demonstrated ordered rating scale functioning, acceptable to excellent reliability, meaningful separation indices, productive item fit, acceptable person fit, essential unidimensionality and no significant item bias. Although several elevated or misfitting items were identified, particularly in relation to training, Project Quality Plan development, personnel deployment and improvement activities, these items were retained because of their theoretical relevance and contribution to the IPQMS construct.

The study makes a methodological contribution by validating a multi-stakeholder IPQMS instrument for construction projects. It also provides a foundation for subsequent analysis of critical IPQMS processes and empirical structural positioning based on Rasch logit hierarchy.

Future research should build on this validated measurement foundation by examining the logit-based hierarchy of IPQMS processes and developing an empirically supported structural model for IPQMS implementation in construction projects.

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