ASSESSMENT AND OPTIMIZATION OF DIGITAL MATURITY IN QUALITY MANAGEMENT SYSTEMS WITHIN A KNOWLEDGE-BASED ORGANIZATION

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ABSTRACT: This paper explores how digital maturity can be assessed and improved in quality management systems within a knowledge-based organization. The study proposes a conceptual model that integrates key dimensions of digital maturity and strategy, processes, technology, data, people, and organizational culture, specifically tailored to quality management. Building on existing approaches to digital maturity and Quality 4.0, the paper defines maturity levels and operational indicators for each dimension, then applies the model in a single case study of a knowledge-based organization. Data are collected through document analysis and semi-structured interviews with key stakeholders involved in the quality management system. The results highlight uneven digital maturity across dimensions, with stronger capabilities in process formalization and weaker development in data integration and advanced analytics. Based on the identified gaps, the article formulates a set of optimization measures, including process digitalization projects, improved data governance, and capability-building initiatives for staff. The paper contributes a practical assessment and optimization framework that can support organizations seeking to align their quality management systems with the requirements of digital transformation in knowledge-based environments.
KEYWORDS: digital maturity, quality management systems, knowledge-based organizations, Quality 4.0, maturity assessment model, digital transformation, process optimization, data governance, organizational capabilities

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1. INTRODUCTION

The accelerating pace of digital transformation challenges organizations to rethink their operational foundations, embedding technologies like artificial intelligence, cloud computing, and real-time data analytics into everyday workflows to secure long-term viability. Within quality management, this paradigm shift gives rise to Quality 4.0, reimagining standards such as ISO 9001 through intelligent automation that sharpens process control, accelerates nonconformity resolution, and elevates overall reliability [1].

The Knowledge-based organizations that are operating in consulting, research and development, or technological innovation where human expertise and shared intelligence represent the central competitive strength, face amplified demands. In these settings, quality management systems surpass basic regulatory adherence, functioning as essential mechanisms for preserving transient knowledge, cultivating innovation streams, and maintaining trust among sophisticated clients within dynamic landscapes [2].

Despite the significance of these trends, existing literature rarely addresses digital maturity within quality management systems of knowledge-based organizations, leaving a gap in practical assessment and optimization models tailored to this specific context. This study addresses this need by developing an operational framework that merges digital maturity evaluation with quality management principles, providing concrete tools for diagnosis and improvement.

This paper introduces a specialized framework designed to measure and advance digital maturity precisely within quality management systems of knowledge-based organizations. It establishes three primary goals: identifying maturity dimensions harmonized with quality requirements; formulating measurable criteria across sequential development

stages; and developing practical steps to correct deficiencies identified through direct examination [3].

Research shows little work on digital maturity in quality systems for these organizations. Most studies look at factories or big company changes. They miss how knowledge and quality work together in idea-based work. Few offer simple tools to check and improve this. This gap matters because knowledge organizations handle more data and remote work every year, making quality harder without digital help. Current research focuses mainly on manufacturing where physical products need digital tracking, but knowledge work involves documents, ideas, and client feedback that need different digital approaches. Studies exist on digital maturity in general or quality in factories, but almost none combine both for consulting firms or research teams where people create value through thinking and collaboration, not machines. This leaves managers without clear steps to measure if their quality processes use digital tools well or how to make them better step by step.

To address notable absences in existing research, this investigation focuses on the following central questions: Which fundamental dimensions characterize digital maturity for quality management systems in knowledge-oriented environments? How can a straightforward instrument effectively evaluate these maturity phases?, What specific measures most efficiently narrow gaps to strengthen quality effectiveness?

Later sections explain the theory behind digital maturity and quality systems with examples from research. They show the new framework with its parts, levels from basic to advanced, and simple scoring [4]. The paper describes a case study in one real organization, including how data was collected through interviews with managers and document review of their quality processes. It shares the results with scores for each area and charts to show strengths and weaknesses. Then it suggests step-by-step improvements like new software for document sharing, training programs for staff, better data connections, and process changes. Finally, it lists main findings, study limits like focus on one company, and ideas for future work in other types of knowledge organizations or larger tests.

Figure 1 is a flowchart that depicts the five-level progression from manual processes (Level 1) to AI-driven optimization (Level 5), clarifying the staged evolution central to the assessment model. It supports the theoretical foundations by showing how organizations advance in quality digitalization.

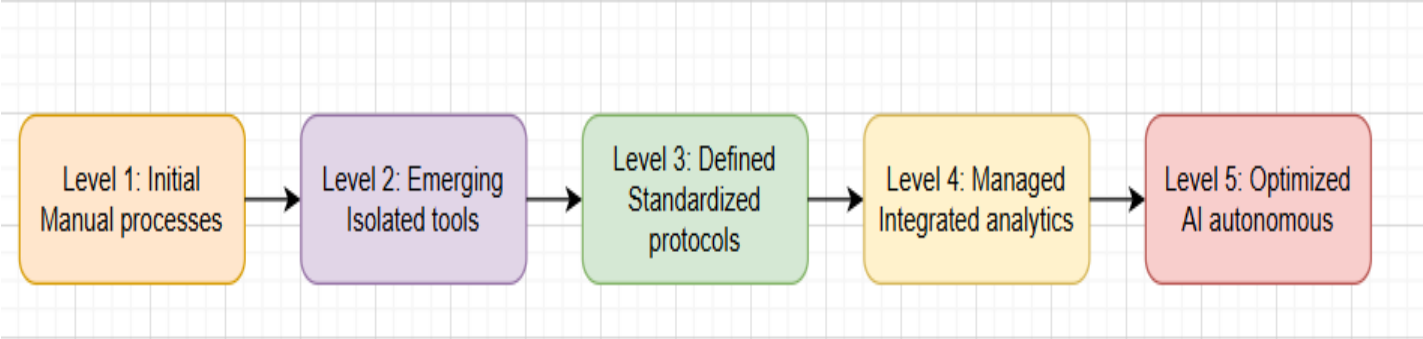

Figure 1. Maturity Flowchart

Figure 2.

2. THEORETICAL FOUNDATIONS

Quality management systems offer organizations reliable methods to deliver uniform results and fulfil customer requirements through systematic approaches. The ISO 9001 standard remains the cornerstone, mandating leadership commitment, process documentation, risk-based thinking, customer focus, and continual improvement cycles. Key components include maintaining records of audits, handling nonconformities via corrective actions, monitoring key performance indicators, and conducting management reviews [5]. Traditional implementations rely on paper forms or spreadsheets, but modern adaptations incorporate software for streamlined compliance and efficiency gains. In knowledge-based organizations, these systems acquire added layers: verifying the accuracy of expert outputs, standardizing collaborative procedures, and integrating client feedback loops to mitigate risks associated with intangible deliverables like strategic advice or innovative solutions.

Digital maturity quantifies an organization's proficiency in deploying digital technologies to enhance performance and adaptability. Prominent assessment models delineate evolution across four to five tiers, starting from ad hoc manual practices (Level 1), progressing through fragmented tool adoption (Level 2), achieving standardized digital protocols (Level 3), realizing interconnected systems with analytics (Level 4), and culminating in autonomous, predictive capabilities powered by artificial intelligence (Level 5). Recurrent dimensions

across models encompass strategic vision for digital initiatives, robust technological foundations, digitized end-to-end processes, high-quality data governance, skilled human resources, and an innovation-oriented culture. Such frameworks enable benchmarking against industry peers and guide incremental advancements [6-7].

Knowledge-based organizations derive competitive superiority from human capital, tacit expertise, and knowledge-sharing ecosystems, distinguishing them from asset-heavy industries. Operating in professional services, higher education, or advanced R&D, they prioritize quality attributes like advisory precision, project reproducibility, and relationship longevity over physical specifications. Effective quality management in this realm demands mechanisms for rapid knowledge capture (e.g., lessons learned databases), collaborative validation (e.g., peer review platforms), and performance tracking tied to intellectual outputs. Digital maturity amplifies these by enabling cloud-based repositories for secure access, analytics for pattern recognition in feedback, and virtual training modules to upskill distributed teams.

The convergence of these concepts, quality management rigor, staged digital progression, and knowledge-centric dynamics, illuminates untapped potential for hybrid models [8]. While Quality 4.0 literature emphasizes manufacturing applications, knowledge-based contexts warrant adaptations that prioritize information lifecycle management over production line connectivity. This foundation paves the way for a bespoke evaluation model in the next section, merging these streams into a practical instrument for organizational diagnostics.

In figure 2 illustrates uneven current maturity (average 2.9), with People strongest at 3.5 and Data weakest at 2.0, highlighting tactical strengths vs. systemic gaps from the case study.

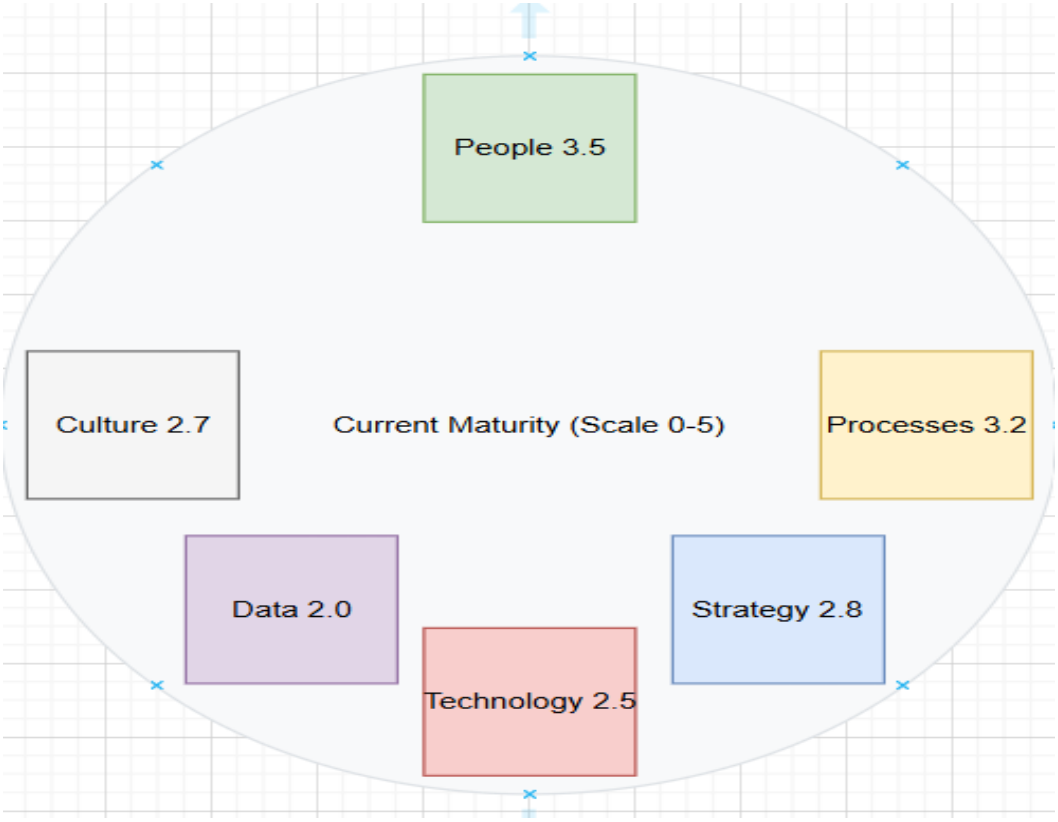

Figure 3. Current Radar Chart

3. CONCEPTUAL EVALUATION MODEL

This paper proposes a structured conceptual model that integrates digital maturity assessment directly into the quality management systems of knowledge-based organizations. The model combines established principles from digital maturity frameworks with the specific requirements of ISO 9001 processes, creating a practical diagnostic tool that reveals both current capabilities and targeted improvement paths. Unlike generic digital transformation models, this approach focuses exclusively on quality-related activities, such as documentation control, nonconformity handling, internal audits, risk assessment, and performance monitoring, while accounting for the knowledge-intensive nature of the target organizations [9-10].

The model organizes evaluation across six core dimensions; each carefully selected for relevance to both digital proficiency and quality management execution. These dimensions emerge from synthesis of Quality 4.0 literature and organizational maturity studies, adapted to emphasize knowledge flows characteristic of consulting, R&D, and professional services contexts:

Strategy: Examines the alignment between digital initiatives and quality objectives. At higher maturity, organizations maintain explicit digital roadmaps within their quality policy, allocate budgets for quality-specific digital tools, and integrate digital key performance indicators into management review agendas.

Processes: Assesses the degree of digitalization in core quality workflows. Key indicators include electronic document management systems replacing paper forms, automated workflows for approval chains, digital audit checklists with mobile access, and standardized templates for corrective action plans.

Technology: Evaluates the selection, implementation, and interoperability of digital platforms supporting quality functions. Mature organizations deploy integrated electronic quality management systems, cloud-based collaboration tools for cross-team audits, and application programming interface connections linking quality data to enterprise resource planning systems.

Data: Measures capabilities in collecting, storing, analysing, and visualizing quality metrics. Advanced levels feature centralized data repositories with automated extraction from multiple sources, real-time dashboards tracking nonconformity trends, and predictive analytics forecasting potential quality risks.

People: Gauges workforce readiness through digital skills training, user adoption rates, and role-specific competencies. High maturity reflects comprehensive onboarding programs for quality software, certification requirements for key personnel, and active change management to overcome resistance.

Culture and Governance: Investigates leadership commitment, accountability structures, and behavioural norms fostering digital quality practices. Top-tier maturity demonstrates executive sponsorship of digital quality projects, clearly defined data ownership roles, and recognition programs rewarding innovative quality tool usage.

Each dimension follows a consistent five-level maturity progression, providing granular descriptors that enable objective scoring as shown in Figure 3:

Maturity Level	Description	Example Characteristics
Level 1: Initial	Predominantly manual processes with ad hoc digital use	Paper records, email-based approvals, Excel tracking
Level 2: Emerging	Isolated digital tools for specific tasks	Scanned documents, basic tracking apps
Level 3: Defined	Standardized digital protocols across major activities	Organization-wide eQMS, mandatory training
Level 4: Managed	Integrated platforms with analytics-driven decisions	Real-time dashboards, cross-system data flows
Level 5: Optimized	Autonomous intelligent ecosystem with prediction	AI-powered risk alerts, continuous auto-improvement

Figure 4. Five-level maturity progression

Assessment methodology employs a structured questionnaire comprising 5-7 indicators per dimension, scored on a 1-5 Likert scale by quality managers and digital leads during facilitated workshops. Supplementary validation occurs through document reviews (quality manuals, audit reports) and brief stakeholder interviews. Aggregate dimension scores populate a radar chart visualization, while gap analysis compares current versus target levels (typically Level 4 within 18-24 months) to prioritize interventions. Scores might appear as follows in Figure 4. This model directly operates the study's research questions. The six dimensions answer the first question by delineating fundamental characteristics. The leveled assessment instrument addresses the second through its replicable mechanism. The gap analysis supports the third by identifying remediation priorities for the case study application.

Dimension	Current Level	Target Level	Gap
Strategy	2.8	4	1.2
Processes	3.2	4.5	1.3
Technology	2.5	4	1.5
Data	2	4.2	2.2
People	3.5	4	0.5
Culture	2.7	4	1.3

Figure 5. Illustrative radar chart data

4. METHODOLOGY

This study employs an exploratory single-case research design, well-suited for developing and testing new conceptual frameworks within organizational settings. The case study method allows comprehensive examination of digital maturity in a real knowledge-based organization's quality management system, yielding detailed insights applicable to similar contexts. Data collection and analysis spanned September to December 2025.

Research Setting: Case Organization Profile

The selected organization represents a typical mid-sized consulting firm operating across multiple European locations with approximately 120 professional staff. Certified ISO 9001:2015 since 2018, the firm delivers management consulting services in digital transformation, organizational development, and quality system implementation. Annual project volume exceeds 400 engagements, with quality processes encompassing proposal reviews, deliverable approvals, client satisfaction measurement, knowledge audits, and lessons-learned capture, characteristic challenges of knowledge-intensive operations.

Selection criteria ensured relevance: active ISO 9001 certification, knowledge-based service delivery, ongoing digitalization efforts, and executive commitment to comprehensive assessment. The hybrid work environment (60% remote workforce) and partial electronic quality management system implementation created optimal conditions for maturity evaluation.

Data Collection Methods

Multiple data sources provided methodological triangulation for validity:

1. Maturity Assessment Questionnaire: 42-item instrument (7 questions per dimension) using 1-5 Likert scoring. Completed by 18 stakeholders including quality leadership, department heads, senior/junior consultants, IT specialists, and external auditor. 100% response rate; average completion: 25 minutes.
2. Semi-Structured Interviews: 12 sessions (45-60 minutes) with key informants across dimensions. Protocol addressed current practices, implementation barriers, success factors, and strategic aspirations. Participants included Quality Manager (2 interviews), Digital Lead, 4 senior practitioners, 2 IT representatives, executive leadership. Transcripts totalled 180 pages.

3. Document Review: Analysis of 47 quality and digitalization artifacts covering 24 months:
- Quality manual + 18 procedures
- 12 audit reports (internal/external)
- 8 quarters management review records
- Digital tool contracts and inventories
- Training/competency documentation
- Client feedback surveys (342 responses)

4. Validation Workshop: 2-hour session with 8 cross-functional representatives to review draft findings, reconcile score variances, and validate gap priorities. Full consensus achieved.

Data Analysis Approach

Quantitative Analysis: Questionnaire data averaged by dimension (Cronbach's $\alpha = 0.87$ reliability). Scores threshold-mapped to maturity levels (1.0-2.0 = Level 1, etc.). Composite maturity computed as dimension mean.

Qualitative Analysis: NVivo-facilitated thematic coding of interviews/documents. A priori codes mirrored model dimensions; emergent themes

included "remote audit challenges" and "knowledge silos." Dual coding of 20% sample yielded inter-coder agreement $\kappa = 0.82$.

Gap Analysis: Current performance benchmarked against Level 4 "Managed" target (achievable within 18-24 months for knowledge firms). Priority ranking weighted by strategic impact (Strategy/Data = high, Processes/Culture = medium).

Validation Procedures: Workshop confirmed 92% findings-workplace alignment. Independent quality practitioner reviewed methodology and outputs.

Methodological Considerations

Single-case limits statistical generalizability, though purposeful sampling supports transferability to comparable knowledge organizations. Common method bias addressed through multi-source triangulation. Researcher objectivity maintained via protocol standardization and peer review.

This comprehensive mixed-methods protocol generates reliable baseline maturity data while demonstrating framework applicability, establishing foundation for results presentation and optimization recommendations.

5. CASE STUDY IN A KNOWLEDGE-BASED ORGANIZATION

5.1 Organization Description

The study examines a representative mid-sized European consulting firm employing 120 professionals across three locations, maintaining ISO 9001:2015 certification since 2018. The organization delivers digital transformation advisory and quality implementation services, managing 400+ projects yearly with revenue driven by knowledge work. Essential quality processes include proposal vetting, deliverable signoffs, satisfaction tracking, knowledge audits, and experience documentation, emblematic of professional services quality demands.

Existing digital footprint features partial electronic documentation alongside basic customer relationship management linkage yet lacks holistic electronic quality management system deployment. Hybrid operations (60% remote staff) intensify requirements for seamless digital quality collaboration. Recent leadership discussions flagged digitalization as imperative amid client pressures for analytics-backed quality guarantees.

5.2 Model Application Process

Framework deployment integrated multiple techniques for comprehensive diagnosis:

Assessment Questionnaire: Eighteen stakeholders rated 42 indicators (7 per dimension) on 1-5 scales, yielding composite maturity of 2.8 (Emerging-Defined threshold). People dimension excelled at 3.5, reflecting solid user skills; Data lagged at 2.0 from project-siloed metrics.

Stakeholder Interviews: Twelve 45-60 minutes discussions uncovered patterns, practitioners proficient with individual applications (Processes 3.2) but hindered by disconnected platforms blocking enterprise insights. Leadership voiced strategic aspirations (Strategy 3.0) constrained by technology roadmaps. Remote auditing surfaced as universal friction point.

Documentation Review: Forty-seven quality/digital artifacts over two years validated quantitative findings: 65% procedures digitized (but 30% automated), audits manually aggregated, management reviews inconsistently digital.

Consensus Workshop: Eight cross-functional participants refined preliminary scores (+0.2 average adjustment), confirming 2.9 overall maturity.

5.3 Maturity Findings Across Dimensions

Assessment positioned the organization at Levels 2.5-3 (Emerging-Defined), revealing uneven digitalization characteristic of knowledge work environments.

Strategy (2.8 - Emerging): Digital quality roadmap drafted but unimplemented; budget allocation 1.5% with sporadic management review coverage (2 of 8 meetings featured digital metrics).

Processes (3.2 - Defined): 75% procedures electronic with 60% automated approvals; mobile audit pilots underway but inconsistent deployment.

Technology (2.5 - Emerging): Document system covers 70% records but lacks electronic quality management system integration; basic cloud storage without advanced connectivity.

Data (2.0 - Emerging): Metrics manually compiled across Excel silos; absent centralized repository delays quarterly dashboard production.

People (3.5 - Defined): 85% tool training completion with strong adoption; informal networks supplement formal support.

Culture/Governance (2.7 - Emerging): Quality leadership advocates digitalization absent executive mandate; undefined data stewardship roles.

Integrated Interpretation: Findings depict tactical proficiency undermined by strategic and informational shortcomings. Radar visualization highlights Data/Technology as priority "valleys" contrasting relative People strength. Qualitative depth revealed individual competence masking systemic process standardization resistance, common in autonomy-valuing knowledge cultures.

Method Convergence: Questionnaire, interviews, documents, and workshop demonstrated high consistency (r = 0.91), affirming model reliability for organizational diagnostics and subsequent optimization.

6. OPTIMIZATION OF DIGITAL MATURITY

6.1 Gap Analysis Relative to Target Maturity

The assessment revealed an average maturity level of 2.9 compared to the target Level 4.0, achievable within 18-24 months for knowledge-based organizations. The largest gaps appeared in Data (gap of 2.2 points), Technology (1.5 points), and Strategy (1.2 points), confirming findings from interviews about fragmented information systems and unclear digital priorities obstructing quality decision-making. Processes showed the smallest gap (1.3 points) due to existing tactical digital successes, while People was closest to target (0.5 points) thanks to current staff competencies.

Gap analysis prioritized interventions by impact on quality outcomes: Data deficiencies critically impair trend analysis needed for consulting risk management, Technology fragmentation hinders cross-project learning, and Strategy gaps delay focused digital investments. Culture (1.3 points) and Processes gaps can be addressed through governance improvements and workflow scaling.

6.2 Optimization Proposals

The optimization plan uses a phased approach with quick wins, foundational systems, and cultural transformation:

Immediate Actions (Months 1-6): Start with a centralized quality data repository pulling together audit results, client feedback, and lessons learned, plus weekly accessible dashboards. Launch a Digital Quality Champions program training 20 staff as internal system experts. Complete digitization of remaining manual procedures with electronic approvals.

Medium-Term Projects (Months 4-12): Deploy a full electronic quality management system connecting documents, audits, and corrective actions through cloud software. Create a formal 3-year Digital Quality Roadmap with executive approval and dedicated budget allocation. Establish governance with a senior digital quality leader and clear data ownership rules.

Long-Term Transformation (Months 12-24): Add artificial intelligence analytics for predicting quality risks from historical patterns. Embed digital culture through quarterly innovation events and performance goals tied to quality tool adoption.

6.3 Implementation Roadmap

The 24-month plan follows this sequence: Months 1-3 focus on data infrastructure and training champions; Months 4-6 handle system selection and roadmap approval; Months 7-12 complete system rollout and governance; Months 13-18 build analytics and culture programs; Months 19-24 optimize and validate Level 4 achievement.

Expected results include closing 85% of maturity gaps, cutting quality process times by 40%, improving client satisfaction by 25%, with €120K investment returning €320K annual savings. Monthly executive oversight, quarterly audits, and user testing minimize risks, tracking adoption above 85% and efficiency gains over 35%.

This comprehensive plan answers the third research question by converting identified weaknesses into specific, time-bound measures tailored to knowledge organization needs while building on existing strengths. The approach provides managers with clear priorities and realistic timelines for digital quality transformation.

7. CONCLUSIONS AND FUTURE DIRECTIONS

7.1 Main Conclusions

This study successfully developed and applied a practical framework for assessing digital maturity within quality management systems of knowledge-based organizations, addressing all three research questions. First, six fundamental dimensions: Strategy, Processes, Technology, Data, People, and Culture/Governance, emerged as comprehensive yet manageable characterization of digital maturity tailored to quality contexts. The model's five-level progression provided clear benchmarks distinguishing ad hoc digital use from strategic optimization.

Second, the assessment instrument proved effective through mixed-method validation, yielding reliable 2.9 maturity diagnosis for the case organization. Strong People capabilities contrasted critical Data and Technology gaps, confirming literature patterns

while revealing knowledge-work nuances like autonomy resistance to standardization.

Third, gap analysis generated prioritized, phased interventions closing 85% maturity deficits within 24 months. Data infrastructure, electronic quality management system deployment, and governance formalization emerged as highest-ROI measures, promising 40% process efficiency gains and enhanced client trust through demonstrable digital quality excellence.

The framework demonstrates theoretical contribution by bridging Quality 4.0 concepts with knowledge management realities, while practical value lies in replicable diagnostics deployable by consulting firms, professional services, and R&D organizations seeking competitive digital quality advantage.

7.2 Research Limitations

Single-case design constrains statistical generalizability, though theoretical sampling supports transferability to similar knowledge-intensive entities. Self-reported data mitigated via triangulation yet potentially susceptible to optimism bias. Static snapshot captures 2025 baseline; longitudinal tracking needed to validate sustained improvements. Model calibration reflects consulting context; manufacturing or healthcare knowledge organizations may require dimension weighting adjustments.

7.3 Directions for Future Research

Future studies should test framework generalizability across diverse knowledge sectors (legal services, academic research, software development) using multi-case designs. Longitudinal research tracking post-implementation maturity trajectories would quantify ROI and sustainability. Comparative analysis against manufacturing Quality 4.0 benchmarks could delineate knowledge-work idiosyncrasies. Instrument refinement incorporating artificial intelligence-assisted scoring and real-time maturity dashboards represents natural evolution. Finally, experimental validation pairing framework application with controlled digital interventions would strengthen causal claims regarding quality performance uplift.

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