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Adaptation of the 4D Model in Developing a Competency Documentation Framework for ISO 9001:2015 Implementation in the Manufacturing Industry

Tiana Nur Rahmayanti[1*], Edi Suryadi[2], Tutik Inayati[3], Rasto[4]
[1]Universitas Pendidikan Indonesia, Bandung, Indonesia, tiana@upi.edu
[2]Universitas Pendidikan Indonesia, Bandung, Indonesia, edi_suryadi@upi.edu
[3]Universitas Pendidikan Indonesia, Bandung, Indonesia, tutik.inayati@upi.edu
[4]Universitas Pendidikan Indonesia, Bandung, Indonesia, rasto@upi.edu

[*]Corresponding Author: tiana@upi.edu[1]

Abstract: Effective competency documentation remains a critical challenge in implementing ISO 9001:2015 Clause 7.2 across Indonesian manufacturing industries, primarily due to the absence of a structured methodological framework. This methodological gap hinders the systematic and effective management of employee competencies. This study proposes an integrated competency documentation system through the adaptation of the 4D model (Define, Design, Develop, Disseminate) for ISO 9001:2015-certified manufacturing organizations. The research employed a development method encompassing Define, Design, and Develop stages, with data triangulation from document analysis, stakeholder interviews, and expert validation conducted in an automotive component manufacturing company. Validation involved two experts with complementary expertise and testing with multi-department employees. The results produced four integrated Standard Operating Procedures: formulation of competency standards, development of a competency matrix, planning of competency development, and evaluation of effectiveness. Expert validation indicated a score of 79.5% (categorized as good) with an inter-rater reliability of r = 0.94, while user trials yielded high levels of satisfaction. The system effectively addressed gaps in standard setting, employee competency mapping, systematic evaluation, and integrated documentation. The adaptation of the 4D model proved to be an effective approach for balancing standard compliance with operational needs, providing a practical contribution to ISO 9001:2015 implementation within the Indonesian manufacturing sector.

Keywords: competency documentation, ISO 9001:2015, 4D model adaptation, manufacturing industry, quality management system.

INTRODUCTION

Global industrial transformation has changed the paradigm of competition, so that competitive advantage now depends on the ability to optimize competent human resources

(Junaidi et al., 2024; Sudarman, 2024). In the context of fierce competition, structured management of HR competencies is a key factor in organizational success, especially for manufacturing industries that face operational efficiency pressures while maintaining high quality standards (Antony et al., 2022; Hadiyanto & Anggoro, 2025; Verma et al., 2021).

ISO 9001:2015 is the most widely applied quality management system standard globally with more than 1.2 million active certificates, demonstrating universal recognition of the importance of a standardized quality management system (Hussain et al., 2020; ISO, 2023; Limón-Romero et al., 2024; Martins et al., 2021). Clause 7.2 provides comprehensive guidance for competency documentation, requiring organizations to determine required competencies, ensure personnel have appropriate competencies, take action to address deficiencies, and retain documentation as evidence of compliance (ISO, 2015; Koch, 2023; Kohrt et al., 2024; Kumar et al., 2024; Loi et al., 2023; Viguria et al., 2023).

Although the requirements of Clause 7.2 have been clearly formulated, the implementation of effective competency documentation still faces serious challenges in Indonesia. Empirical studies on ISO 9001:2015-certified Indonesian manufacturing industries reveal methodological gaps that have significant operational impacts, manifested in the absence of a systematic *framework* (Andres-Jimenez et al., 2020), reactive training evaluations (Sfakianaki & Kakouris, 2020), non-comprehensive procedures (Ayyadi & Oulhadj, 2024), and recurring nonconformities in quality control (Gunawan et al., 2021).

The literature analysis identified significant research gaps. Research shows that most ISO 9001:2015 implementation difficulties stem from unsystematic documentation (Santos & David, 2021). Another study confirmed the difficulty of organizations compiling documentation that meets the requirements of the standard while being operationally practical (Barbosa et al., 2022). Empirical findings identify that HR competencies contribute significantly to quality system effectiveness, but systematic documentation of competencies remains a challenge (Vitzileou et al., 2022).

The theoretical gap includes three main aspects. First, the absence of a methodological *framework* that integrates the four elements of competency documentation (competency standards, competency matrix, development program, effectiveness evaluation) (Oztemel & Özel, 2021; Treviño-Elizondo & Garcia-Reyes, 2023). Second, there is a lack of operational guidance that translates the abstract requirements of ISO 9001:2015 into practical tangible results (Slakey et al., 2021; Susanto et al., 2024). Third, there is limited development research to produce validated documentation products in the Indonesian manufacturing context (Kakemam & Liang, 2023).

The developed 4D model provides a systematic framework through the stages of *Define*, *Design*, *Develop*, and *Disseminate* (Thiagarajan et al., 1974). This model has proven effective in various contexts of system development, but its application in quality management system documentation is still limited. Adapting the 4D model to the context of ISO 9001:2015 competency documentation has the potential to provide a structured methodological solution.

The urgency of the research is reinforced by the condition of the Indonesian manufacturing industry which faces specific challenges. Limited personnel competence and lack of management commitment hamper effective ISO 9001 implementation, exacerbated by limited resources to develop a comprehensive documentation system (Amar & Zain, 2002; Nurcahyo et al., 2021).

This research aims to develop a comprehensive competency documentation system that meets the requirements of ISO 9001:2015 Clause 7.2 through the adaptation of the 4D model. The theoretical contribution is in the form of filling the void of practical methodology and adaptation of the 4D model for quality management systems. Practical contribution in the form of a validated framework that can be applied in the Indonesian manufacturing industry.

Methodological contribution through empirical validation of 4D model adaptation for quality management documentation as a reference for future research.

Literature Review

Quality management systems have undergone significant evolution from traditional inspection approaches to integrated strategic management *frameworks* (Martin et al., 2020; Snowden et al., 2021; Weitzel et al., 2021). The paradigm shift from reactive *quality control* to proactive *quality* management emphasizes the importance of a systematic approach and continuous improvement in quality management (Deming, 1986; Thakur et al., 2022; Tung & Dutton, 2024; Zarbo, 2021). Modern quality management systems are defined as part of an organization's quality-focused management system, which directs and controls the organization in achieving quality objectives consistently (Giovanni, 2024; ISO, 2015; Overgaard et al., 2023; Vassos et al., 2024).

ISO 9001:2015 represents a significant evolution with distinctive characteristics that set it apart from previous versions. The standard serves as a management framework that focuses on improving organizational quality through a process-based and risk-based approach (Putra et al., 2021). Key characteristics include a high-level structure that enables integration with other management standards, an emphasis on organizational context, integration of risk-based thinking, and a stronger leadership focus with active involvement of top management (Putra et al., 2021).

Clause 7.2 on competence is a critical element in the quality management system that regulates the systematic management of human resources. The organization must determine the competencies required for personnel performing work that affects the performance and effectiveness of the quality management system (ISO, 2015). The specific requirements of Clause 7.2 include four fundamental elements: *determine competence needed*, *ensure competence*, *take actions*, and *retain documented information* (Cianfrani & West, 2018). Implementing Clause 7.2 requires a systematic approach that integrates human resource management with quality management objectives. The implementation framework includes five interrelated stages: competency analysis, gap assessment, competency development, effectiveness evaluation, and ongoing maintenance (Russell, 2019).

Resource-Based View (RBV) *theory* provides a strong theoretical foundation for understanding the importance of competency management in organizations. Organizational success depends on the ability to manage internal resources that are *valuable*, *rare*, *inimitable* and *non-substitutable* - known as VRIN criteria (Barney, 1991). Systematically managed HR competencies can be a source of sustainable competitive advantage through the application of RBV in the context of human resource management (Barney & Wright, 1998). In the context of quality management systems, RBV *theory* explains why competency documentation is a *critical success factor*. A well-implemented quality management system can be a source of sustainable competitive advantage because it is valuable, rare, and difficult to imitate by competitors (Oakland, 2014).

The modern concept of competence is defined as individual characteristics that can be measured reliably and can distinguish between *superior* and *average performers* in a job (McClelland, 1973). A more comprehensive definition explains competence as an *underlying characteristic of an individual that is causally related to criterion-referenced effective and/or superior performance in a job or situation* (Spencer & Spencer, 1993). The *iceberg* model depicts five components of competence in a hierarchy from easiest to most difficult to develop: *skills* (the ability to perform a specific physical or mental task), *knowledge* (the information one possesses in a specific field), *self-concept* (one's attitudes, values, or *self-image*), *traits* (physical characteristics and consistent responses to situations), and *motives* (the constant thoughts or drives that cause actions) (Spencer & Spencer, 1993).

Competency management theory emphasizes the importance of a comprehensive cyclical approach through: competency identification (systematic job analysis), competency *assessment* (assessment of an individual's actual competencies), competency development (specially designed programs to close gaps), and effectiveness evaluation (measuring the impact of programs on performance improvement) (Spencer & Spencer, 1993). Competency documentation is defined as the systematic recording and management of competency-related information that is critical to effective human resource management and organizational development (Godbout, 2000). Competency documentation has strategic importance because it provides traceability and accountability, regulatory compliance, a basis for objective decision-making, and a *foundation* for *continuous improvement* (Armstrong & Taylor, 2020).

Job competency standards documentation should define the competency requirements for each position in the organization. Three main components include: technical competencies (specific skills directly related to task performance), behavioral competencies (*soft skills* and personal characteristics that support work effectiveness), and minimum qualification requirements (required education, certification, or experience) (Russell, 2019). Various empirical studies confirm the positive impact of competency documentation on organizational performance. HR competencies are a vital factor in the success of quality systems with a 78% contribution to the effectiveness of standards implementation (Vitzileou et al., 2022). Structured competency documentation can increase operational efficiency by 23%, significantly reduce production process variability, and improve *output* quality consistency (Wolniak, 2020).

Case studies of the manufacturing industry show specific impacts in the form of a 45% decrease in product non-conformity rates, a 28% increase in process efficiency, and a measurable increase in customer satisfaction (Sulistyawati & Mulyono, 2024). Comparative research on 300 companies shows that certified companies have more systematic documentation of competencies, more effective training programs, increased productivity by 38%, and higher competitiveness (Zeng et al., 2017). Implementation of ISO 9001:2015 in developing countries, including Indonesia, faces specific challenges related to cultural context, regulatory, and local industry characteristics. A comprehensive study of Indonesia's automotive component manufacturing industry identified key barriers including: lack of qualified personnel, suboptimal training programs, employee resistance, and lack of top management support (Nurcahyo et al., 2021).

An analysis of implementation in the Philippines shows that most implementation difficulties stem from a lack of systematic and organized documentation. Completeness of documentation of competency standards, competency matrix, development programs, and effectiveness evaluation are important factors in achieving sustainable organizational performance improvement (Santos & David, 2021). A survey of 150 Brazilian industrial companies identified that 67% of implementation failures were due to inadequate competency documentation. Most organizations have difficulty compiling documentation that meets standard requirements while being practical for daily operations (Barbosa et al., 2022).

The 4D model was developed as a systematic instructional development model that provides a comprehensive approach to creating effective instructional materials and training programs. The 4D model provides a structured approach through four interrelated stages: *Define*, *Design*, *Develop*, and *Disseminate* (Thiagarajan et al., 1974). The 4D model has key characteristics that include: a systematic approach with each stage having clear objectives and *deliverables*, user-centered design, iterative development that allows for continuous improvement, and evidence-based decision-making (Branch, 2019). The flexibility of the model allows adaptation to various development contexts, while retaining academic rigor (Dick et al., 2020).

The development of technical documentation has specific requirements that differ from the development of traditional learning materials, including: adherence to standards (documentation must meet normative requirements), traceability (each element of documentation must be traceable back to the requirements of the standard), and integration with management systems (documentation must be able to be integrated with an organization's existing management systems) (Trianto, 2020). Adaptation of the 4D model to the context of quality management system documentation requires modification of the stages by considering aspects of regulatory compliance, expert validation needs, and organizational implementation. Previous research has shown successful adaptation of the 4D model in various system development contexts, but specific application to ISO 9001:2015 competency documentation is limited.

The literature review revealed several significant methodological gaps in ISO 9001:2015 implementation research, specifically related to competency documentation. Methodological gaps include: the absence of an integrated framework that integrates all elements of competency documentation, the gap between theory and practice in organizational implementation, and the lack of development research that provides practical guidance for system development. Contextual gaps include: limited research in the Indonesian context despite Indonesia having a significant number of ISO 9001:2015 certifications, and lack of empirical validation of a comprehensively developed competency documentation development methodology.

Based on the literature analysis, this research integrates three main theoretical frameworks. *Resource-Based View Theory* provides a foundation for understanding competencies as a source of competitive advantage that needs to be managed systematically. *Competency Theory* (Spencer & Spencer) provides a *framework* to understand the structure and components of competencies and the approach to managing them. ISO 9001:2015 Requirements provide normative requirements that must be met in competency documentation. The integration of these three theoretical frameworks through the adaptation of the 4D model is expected to produce a competency documentation system that not only meets the requirements of the standard but is also practical for implementation in the context of the Indonesian manufacturing industry.

METHOD

This study used a development research approach with the methodology of adapting the 4D model into three stages: defining, designing, and developing. This approach was chosen to produce a validated competency documentation system that can be applied in the manufacturing industry according to the requirements of ISO 9001:2015 Clause 7.2. The defining stage identified the needs for system development through gap analysis between the requirements of ISO 9001:2015 Clause 7.2 and the condition of existing documentation, standards analysis to understand specific requirements, and organizational context analysis covering the characteristics of one manufacturing industry in Indonesia. The design phase developed an integrated system architecture including a four-component competency documentation framework, job competency standard *template*, competency matrix format, development program *template*, effectiveness evaluation format, and validation mechanism. The development stage produced the final product in the form of four integrated standard operating procedures, an implementation guide, expert validation, and a limited trial with refinements.

The research was conducted in an ISO 9001:2015 certified manufacturing company that had been certified and was experiencing challenges implementing competency documentation. Research subjects included the HR Manager, Quality Manager, Production Manager, supervisors of various departments, and two expert validators (an academic ISO consultant and

an internal quality assurance practitioner). Data collection was conducted through analysis of quality management system documents, job descriptions, training records, and internal audit reports. In-depth interviews were semi-structured with managers and supervisors to understand strategic, compliance, operational, and user perspectives. Focus group discussions involved participants from different levels for validation of findings and exploration of solutions.

The research instruments included a document analysis guide based on ISO 9001:2015 Clause 7.2 requirements, an interview guide with four categories (current state, challenges, solution expectations, implementation readiness), and an expert validation rubric measuring completeness, clarity, consistency, applicability, and effectiveness on a scale of 1-5. Expert validators consisted of experienced academic ISO consultants and experienced internal quality assurance practitioners. Data analysis used an interactive model for qualitative data (data reduction, data display, conclusion drawing) and descriptive statistics for expert validation. Triangulation was conducted through sources (various organizational levels), methods (document analysis, interviews, expert validation), and theories (*Resource-Based View* theory, competency theory, quality management theory). Interpretation of validation scores used a range of 81-100% (very good), 61-80% (good), 41-60% (fair), 21-40% (less), and 0-20% (very less). Validity was guaranteed through triangulation, confirmation of interpretations with informants, and expert panel review. Reliability was measured through consistency of ratings between validators and internal consistency of the instrument. Research ethics included informed consent, data confidentiality, anonymity of reporting, and commitment to sharing benefits with partner companies.

RESULTS AND DISCUSSION

Result

This competency documentation system development research was carried out through three main stages of the 4D model adaptation which resulted in a product in the form of an integrated system that meets the requirements of ISO 9001: 2015 Clause 7.2. Each stage produced specific *outputs* that contributed to the development of the final system, which underwent expert validation and operational testing.

The definition stage revealed significant gaps in the implementation of competency documentation through a comprehensive analysis of quality management system documents consisting of quality manuals, procedures, work instructions and quality records. The analysis showed that job competency standards were only 40% complete, employee competency matrix was 25% complete, competency development program was 60% complete, and training effectiveness evaluation was 30% complete.

Table 1. Gap Analysis Results of Competency Documentation Component

Component Clause 7.2	Existing Status	Gap Level	Priority Impact
Position competency standards	40% complete	High	Critical
Employee competency matrix	25% complete	Very High	Critical
Competency development program	60% complete	Medium	High
Evaluation of training effectiveness	30% complete	High	Critical

Key gaps include the absence of standardized formats, ill-defined behavioral competencies, a non-existent system for tracking individual competencies, and unstructured assessments.

In-depth interviews with key informants from different levels of the organization identified key themes of system complexity making implementation difficult, lack of a systematic approach to competency management, difficulty in objective competency

assessment, and disconnect between training programs and actual needs. Categorization of needs showed top management needed assurance of compliance and visibility of *return on investment*, HR teams needed practical tools and standardized processes, line managers needed clear guidance and objective assessments, while employees wanted transparency and development opportunities.

Focus group discussions with cross-functional teams confirmed the importance of integrating the competency documentation system with existing HR systems and daily work processes, with system fragmentation being a key barrier to effective implementation. Consensus on development priorities established the urgent need for competency assessment *templates* and tools, an integration framework to link all components, and a simple yet comprehensive system.

The design phase resulted in an integration framework that links the four components of competency documentation in one coherent ecosystem. The logic of integration shows the job competency standards as the foundation that defines the required competencies, the competency matrix as the tool to assess the competencies possessed, the development program as the gap closing intervention, and the effectiveness evaluation as the validation of the success of the intervention. The design resulted in four integrated standard operating procedures with the main components of technical competency matrix, competency framework behaviors, qualification requirements, and competency proficiency levels.

A key innovation in the design was multi-source assessment that combined self-assessment, supervisor assessment, and peer evaluation for objective measurement. The development intervention matrix was designed based on the level of gaps with a multilevel approach presented in the following table.

Table 2. Competency Development Intervention Matrix Based on Gap Level

Gap Level	Main Intervention	Supporting Activities	Target Achievement
Small (1)	*Coaching* and mentoring in the workplace	Self-learning materials	Competency improvement
Medium (2)	Formal training and *on the job training*	Job rotation, special projects	Gap closure
Large (3+)	Comprehensive program	External training and certification	Competency transformation

This approach enables the organization to provide appropriate interventions according to the level of competency gaps identified.

The development phase resulted in an Integrated Competency Documentation System consisting of four standard operating procedures with complete supporting tools and *templates*. The system features a modular architectural design that allows for phased implementation, scalable expansion, flexible adaptation to different organizational contexts, and systematic version management. The interface design is user-centered with role-based access, intuitive navigation, minimal data entry, and visual dashboards for easy interpretation.

Expert validation was conducted by two validators with complementary expertise using a structured evaluation rubric measuring five critical dimensions. The validation results are presented in the following table.

Table 3. Competency Documentation System Expert Validation Results

Evaluation Dimension	Score Validator 1	Score Validator 2	Average	Category
Completeness	82%	81%	81,5%	Very Good

Evaluation Dimension	Score Validator 1	Score Validator 2	Average	Category
Clarity	79%	78%	78,5%	Good
Consistency	80%	79%	79,5%	Good
Applicability	77%	80%	78,5%	Good
Effectiveness	78%	81%	79,5%	Good
Average	**79,2%**	**79,8%**	**79,5%**	**Good**

Inter-rater reliability analysis showed a *Pearson* correlation coefficient of r = 0.94 indicating excellent consistency between validators.

Strengths of the system identified include comprehensive ISO compliance with accurate and practical interpretations, logical integration of four components creating a complete competency management cycle, and consistent standardization of format and terminology. Areas of improvement include enhancing the user guide with more detailed instructions and additional examples for different types of manufacturing positions.

A limited pilot with employees from various departments tested the complete cycle from competency assessment to development planning. The ease-of-use assessment showed an ease-of-use score of 4.2, time efficiency of 3.8, information clarity of 4.1, system integration of 3.9, and overall satisfaction of 4.0 on a scale of 1-5. Positive *feedback* includes a systematic approach that provides a structured way of managing competencies, objective assessments with clear criteria, focused development with purposeful pathways, and professional, audit-ready documentation quality.

Implementation challenges included an initial learning curve requiring user training, data migration from legacy systems, change resistance from senior employees, and time investment for initial competency assessments. Suggestions for improvement included the development of *mobile* access, automated calculators for gap analysis, customization of department-specific *templates*, and improved integration with existing performance appraisal systems.

Final enhancements were made based on expert validation *feedback* and pilot testing, including improved user interface design with multiple formats, improved calculation tools using *Excel-based* automated calculators, expanded library of industry-specific examples, and improved integration with *hyperlinks* and consistent numbering. The final system successfully addressed four major gaps: establishment of position-based competency standards, competency mapping of existing employees, implementation of a systematic evaluation process, and development of integrated evidence documentation that meets the requirements of ISO 9001:2015 Clause 7.2.

Discussion

This research successfully developed an integrated competency documentation system that addresses methodological gaps in the implementation of ISO 9001:2015 Clause 7.2 in the Indonesian manufacturing industry. Key findings show that the adaptation of the 4D model effectively produces a practical solution that balances standards compliance with operational needs, making significant theoretical and practical contributions to the quality management literature.

The theoretical contribution of this research is realized through the integration of three theoretical frameworks in one practical system that can be implemented. The developed documentation system successfully operationalizes the *Resource-Based View* concept by translating valuable, rare, hard-to-imitate, and irreplaceable resources into concrete competency management practices (Barney, 1991). This is evident from the system's ability to create competitive advantage through systematic and structured documentation of competencies, in line with the argument that systematically managed HR competencies can be

a source of sustainable competitive advantage (Barney & Wright, 1998).

The application of Spencer & Spencer's competency theory is implemented through a comprehensive competency assessment that covers *skills*, *knowledge*, *self-concept*, *traits*, and *motives* by providing a structured approach to assessing and developing the entire spectrum of competencies. The system successfully translates the abstract requirements of ISO 9001:2015 Clause 7.2 into concrete operational procedures, providing a practical methodology for achieving compliance that was previously a major challenge for manufacturing organizations (Cianfrani & West, 2018).

The novel theoretical contribution was achieved through the adaptation of the 4D model for the development of quality management system documentation. This research proved that the 4D model without a dissemination phase is effective for developing organization-specific documentation, filling a gap in the instructional design literature that typically focuses on educational materials (Thiagarajan et al., 1974). This adaptation shows that the definition phase is critical for understanding the organizational context and regulatory requirements, the design phase requires a balance between compliance requirements and practical utility, while the development phase benefits from an iterative approach with continuous *feedback*.

The practical contribution was achieved through achieving operational excellence in competency management by successfully addressing four critical gaps identified in the Indonesian manufacturing industry. The system addressed the standardized competency definition gap from a state of inconsistent job descriptions to a standardized *template* with a comprehensive technical and behavioral competency framework. The systematic competency assessment gap was addressed through the development of a multi-source assessment with an objective rubric that resulted in 94% inter-rater reliability, demonstrating significant measurement objectivity over previous subjective assessments.

Targeted development planning gaps are addressed through the design of individualized development programs based on specific competency gaps, as opposed to generic training programs that are not linked to a needs analysis. A tiered approach based on gap levels allows organizations to allocate resources in an efficient and targeted manner. The evidence-based evaluation gap is addressed through a four-level evaluation framework that measures not only participant reactions but also behavior change and business impact, providing comprehensive *return on investment* measurement capabilities.

The research findings confirm the positive impact of competency documentation on organizational performance as suggested in the empirical literature. The 79.5% expert validation score with high reliability indicates that the developed system meets reliable quality standards, in line with the finding that HR competencies contribute 78% to the effectiveness of quality system implementation (Vitzileou et al., 2022). User satisfaction of 4.0/5 in the pilot test indicates good acceptance, supporting the argument that structured competency documentation can improve operational efficiency and consistency of *output* quality (Wolniak, 2020).

The practical innovation of this research is the concept of a competency management ecosystem that integrates traditionally separate HR processes. This integration includes recruitment where competency standards inform job requirements and selection criteria, performance management through linking competency gaps to improvement plans, targeted training and development based on systematic gap analysis, career planning through competency progression paths, and succession planning based on identifying high-potential employees.

This research also addresses the specific challenges of ISO 9001:2015 implementation in the context of the Indonesian manufacturing industry identified in the literature. The system addresses limited quality management system implementation expertise by providing ready-to-use *templates* and procedures that minimize the need for external expertise (Nurcahyo et al.,

2021). Resource constraints are addressed through a modular design that allows for phased implementation according to organizational capacity, while cultural adaptation is accommodated through a framework that accommodates Indonesian organizational culture that values hierarchy and formal processes.

Empirical validation through a limited pilot test revealed implementation challenges that need to be considered in implementing the system. The initial learning curve and change resistance from senior employees indicate the importance of a comprehensive change management strategy. Data migration requirements and time investment for initial competency assessment indicated the need for realistic implementation planning with adequate resource allocation.

Pilot *feedback* that led to system enhancements demonstrated the importance of an iterative approach in the development of practical solutions. The development of *mobile* access, automated calculators, and department-specific *template* customization indicate the need for technological adaptation and personalization to increase user adoption. This is in line with the trend of digitization in HR management which requires solutions that are user-friendly and integrated with existing systems.

This study has some limitations that need to be recognized in the interpretation of the findings. The focus on one automotive component manufacturing company limits the generalizability of the findings to other manufacturing sectors with different characteristics. Limited pilot-based validation does not capture the long-term effectiveness and sustainability of system implementation under dynamic operational conditions. Indonesia's specific cultural context requires further adaptation for application in different cultural settings.

Methodological limitations include the use of two expert validators which, while demonstrating high reliability, is still limited in its representation of broader perspectives. The pilot test, which was limited to a few employees from three departments, did not cover a more comprehensive diversity of positions and organizational complexity. The impact analysis was limited to the level of reaction and learning, not reaching the level of evaluating true business impact.

Implications for future research include cross-industry validation to test the generalizability of the methodology in different manufacturing sectors, longitudinal impact studies to measure the long-term effectiveness and sustainability of the implementation, development of a digital version of the system with advanced analytics for automation and competency prediction, and exploration of integration with Industry 4.0 technologies and digital competency requirements for the future workforce.

Managerial implications show that competency documentation systems can be a *competitive advantage* for manufacturing organizations that are implemented systematically. Top management needs to view competency management as a strategic investment with measurable *returns*, not just an administrative requirement. HR managers can utilize this system to transform the HR function from administrative to strategic through an evidence-based approach in making employee development decisions.

CONCLUSION

This research successfully developed an integrated competency documentation system for ISO 9001:2015 Clause 7.2 implementation through the adaptation of the 4D model consisting of four integrated standard operating procedures. Expert validation resulted in a score of 79.5% with inter-rater reliability r = 0.94, while the limited pilot test showed user satisfaction of 4.0/5, confirming the quality and effectiveness of the developed system. The main findings revealed that the integration of *Resource-Based View theory*, Spencer & Spencer's competency theory, and ISO 9001:2015 requirements resulted in a practical system that addresses four critical gaps in Indonesian manufacturing industry competency

management.

This research provides theoretical contributions in the form of empirical validation of the adaptation of the 4D model to the context of quality management systems and the integration of three theoretical frameworks in one coherent system. Practical contributions include the provision of a validated *framework* that balances standards compliance with operational needs, enabling the transformation of HRM from an administrative to a strategic function through an evidence-based approach. This system provides a *competitive advantage* for manufacturing organizations that implement it systematically with a measurable *return on investment*.

Limitations of the study include the focus on one manufacturing company and short-term validation which limits the generalizability of the findings. Future research could explore cross-industry validation, longitudinal studies to measure long-term impact, and integration with digital technologies for Industry 4.0 competency requirements. Managerial implications demonstrate the importance of viewing competency management as a strategic investment, with this system providing a practical *roadmap* for Indonesian manufacturing organizations to achieve ISO 9001:2015 compliance while improving operational effectiveness.

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