ISSN: 2253-0347 مجلـة علوم الإنسان و المجتمع EISSN: 2602-781X
Journal of Human and Society Sciences
volume: 15 /N°: 03 /Year:2026 /pp: 1076-1122

Digital Quality Management: A Pathway to Developing Knowledge Industry in Documentation Institutions Proposed Framework for an Integrated Approach

Received date:06/01/2026 Accepted date01/10/2026 Published date:11/10/2026

Adra bencharef [1]

[1] University of Emir Abdelkader, Algeria ,

Email :a.bencharef@univ-emir.dz

https://orcid.org/ 0009-0004-4570-8165

Abstract:

This study explores the potential of implementing Digital Quality Management (DQM) in documentary institutions to develop their knowledge industry and enhance their role in the knowledge economy. We examined the theoretical foundations of this administrative approach and its implementation challenges, highlighting its pivotal role in addressing obstacles facing the knowledge industry in these institutions. The study concludes that adopting DQM is essential for enabling documentary institutions to build an economically valuable knowledge industry through the proposed framework.

Keywords: Digital Quality Management, Knowledge Industry, Framework, Documentation Institutions

Corresponding Author: adra bencharef, **Email:** a.bencharef@univ-emir.dz

1. INTRODUCTION

Our present era is witnessing profound, unprecedented transformations driven by the rapid and impactful revolution in technology. This has prompted both service-oriented and commercial institutions to urgently adapt to these changes, not only by acquiring the latest digital tools but also by making deep and fundamental organizational, operational, and cultural changes that affect all aspects of their activities and even alter their conventional image. This phenomenon is now referred to as digital transformation, which has become a necessity for existence, a requirement for sustainability, and a competitive advantage in a rapidly changing environment.

In parallel, there has been a growing focus on knowledge as an economic and strategic resource, a fundamental pillar for national development and wealth creation. This has led to the emergence of new concepts and practices, most notably the knowledge industry, which reflects societies' ability to transform ideas and experiences into high-quality knowledge products with added value, along with tangible economic returns. As a result, libraries and archives have gained a prominent position, and society's view of them has shifted, especially as many of these institutions have strived to redefine their roles in line with digital progress and the demands of the knowledge era. They have transitioned from being mere repositories for storing and providing information sources to dynamic centers for knowledge industry, confirming their active role in this industry.

Despite the numerous advantages brought by the triad of technology, digital transformation, and knowledge to documentation institutions, it has also exposed them to unprecedented challenges, particularly in the realm of quality management. Traditional methods suitable for the conventional environment, physical products, and

routine processes are no longer effective in handling knowledge products developed in an advanced, interconnected digital environment. The integration of knowledge and technology has created a complex fabric for business models and various stages of knowledge product creation, making it difficult for conventional quality management approaches to address and adapt to these new dynamics. Therefore, it has become essential to adopt new visions and innovative methods to ensure the efficiency and effectiveness of knowledge industry processes and to guarantee the quality of their products.

In this context, DQM has recently emerged as a modern management approach that not only aligns with digital transformation but is also crucial for achieving its goals. It provides the essential framework for performance enhancement, fosters innovation, reduces waste, ensures data quality, and supports intelligent decision-making. This enhances the ability of institutions to face the challenges of the digital environment and achieve higher quality levels in their products, thereby enabling them to fulfill their future roles effectively.

1.1 Research Problem:

Documentation institutions, in their efforts to keep pace with the rapid changes of the digital age, face numerous internal and external challenges that create a difficult working environment and unfavorable organizational conditions. These challenges hinder their transformation from being a burden on their communities to a source of wealth creation and impede their efforts to meet the growing demands for developing innovative knowledge services that match their new role in the third millennium as centers for knowledge industry.

Thus, libraries and archives must seriously consider adopting modern, innovative management methods that include comprehensive and integrated visions and strategies to overcome internal problems, face external challenges, and support their future directions, particularly in terms of enabling them to develop their knowledge industry. Given the positive results DQM has achieved in several fields such as high-tech enterprise (Васильев & Александрова, 2024) aviation(Андреевич & Викторовна, 2022), construction(Luo et al., 2022; Stransky & Matejka, 2019) health care organizations(Rego & Petzold, 2025) and education(Budarina & Polupan, 2019) , it appears to be a promising option for documentation institutions. Therefore, this research begins with a fundamental question: Can the adoption of DQM in documentation institutions contribute to the development of the knowledge industry?

To answer this essential question, we have posed the following inquiries:

_ What are the conceptual foundations, benefits, and implementation challenges of DQM?

_ What is meant by the knowledge industry in the context of documentation institutions, and what challenges do they face in its development?

_ How can DQM conceptually address the challenges facing the knowledge industry in these institutions, and what integrated framework can be proposed for its effective adoption?

1.2 Study Objectives:

This study examines how documentation institutions can adopt DQM to develop their knowledge industry. We establish a theoretical framework for DQM, identify knowledge industry transition challenges, and explore DQM's expected impact on addressing these challenges. Finally, we propose an implementation framework for

effectively adopting DQM to advance the knowledge industry in documentation institutions.

1.3 Research Methodology:

This study adopts a theoretical and conceptual approach based on an analysis of the relevant literature. Previous research on Digital Quality Management (DQM) was analyzed to define the concept, its benefits, and the challenges of implementing it, while the literature on the knowledge industry was reviewed to clarify the role of documentation institutions within it and the challenges hindering its development. The findings were then conceptually integrated to show how DQM can address these challenges. This integration yielded the proposed framework, which comprises two pathways and several stages, each grounded in a solid theoretical foundation.

1.4 : Research Gap and Contribution

The reviewed literature indicates that DQM has been examined mainly in industrial and service sectors such as high-tech enterprises, aviation, construction, health care, and education (see the studies cited in the Research Problem). In libraries, quality management research has largely addressed service quality and social impact (e.g., Holt, 1996; Jorge-García-Reyes, 2022) rather than DQM as such, while studies on the knowledge industry within documentation institutions remain scarce. However, to the best of our knowledge, and based on a search of international databases [Scopus, Web of Science, …] conducted in October 2025, no previous study has specifically examined DQM in documentation institutions, linked it to the development of the knowledge industry within them, or proposed an integrated approach explaining how DQM can address the challenges facing that industry. This study addresses this gap by (1) adapting the concept of DQM to the context of documentation institutions, (2)

relating the challenges of the knowledge industry to the contributions of DQM, and (3) proposing a conceptual framework, derived from these two steps, that combines a pathway for adopting DQM with a pathway for applying it to develop knowledge products. Accordingly, the study contributes theoretically by extending DQM to a new institutional context, and practically by offering documentation institutions a structured framework to guide their adoption of DQM.

2. Theoretical Framework for Digital Quality Management in Documentation Institutions

2.1 Concept of Digital Quality Management

The literature is filled with numerous terms such as digital quality, digitalization of quality management, digital transformation of quality management, and Quality 4.0. Often, these terms are confused with one another. For instance ,(rmoni, 2024) considers it "a digital process aimed at ensuring that products meet quality standards and are fit for their intended purpose (the traditional concept of quality) by measuring and monitoring performance digitally against defined quality standards and taking corrective actions when necessary."

However, this idea is opposed by many researchers who argue that Digital Quality Management (DQM) is a broader and more comprehensive approach than merely digitizing traditional quality management processes. This is affirmed by Carvalho and his colleagues, who consider it "the application of digital technologies to quality management, impacting its tools and methods on both the technical and human levels."(Carvalho et al., 2020, p. 702). For them, DQM is "the application of Industry 4.0 to quality management itself, including its tools, methods, systems, and its effects on people."

Although the definition above provides a deeper perspective on DQM, its emphasis on it being synonymous with Quality 4.0 can cause confusion, especially since there is no unified and shared

definition of Quality 4.0 that helps differentiate the two. However, most definitions affirm that Quality 4.0 represents an expanded approach to quality management, describing it as "the integration of quality management traits with Industry 4.0, which contributes to improving work efficiency and overall performance as a result of the fundamental transformations technology has made in quality—from traditional methods that focus on one or more improvement objectives to integrated DQM approaches that leverage data and digital technologies to address multiple improvement objectives radically" (Christou et al., 2022) .

In another definition described Quality 4.0 as "the digitization of the traditional quality approach, focusing on the use of digital tools to enhance an organization's ability to meet customer requirements with high quality" (Alzahrani et al., 2021, p. 2)

This means that it does not replace traditional quality methods but adopts and improves them. It certainly involves the digitization of quality management—something we addressed earlier—and, more importantly, its impact on quality technology, processes, and people. This indicates that DQM is not synonymous with Quality 4.0; rather, it is a broader and more inclusive approach.

This is confirmed by Zhang Genbao, who, through research and a thorough review of the literature, was found to be the first to present a clear definition of Digital Quality Management in an article titled "Digital Quality Management and Its Key Techniques" .(Zhang, 2005) He considered that DQM emerged as a crucial approach to addressing current quality management issues in Chinese institutions, involving the integration of digital technologies with traditional quality management methods throughout the product lifecycle.

In a more precise and focused definition, digital quality management is viewed as: "A radical change in the quality management model driven by digital transformation. This management focuses on expanding the scope of quality management and altering its goals and methods to enhance the digital capability of quality management within the organization in the digital environment. It does so by fostering digital thinking, applying digital technology, adjusting the management mechanism, and developing data applications and their usage."(Gao et al., 2024a, p. 55)

Thus, we can say that DQM is not a replacement for traditional quality management nor merely a theoretical advancement in quality thinking or new practices in the digital environment. While its core focus is the intensive use of modern digital technologies to collect and process data and perform analyses to proactively predict and resolve quality issues, it is far more profound than simply applying digital technology to traditional quality practices. It represents a deep transformation in the general perception of quality in the digital environment, a radical change in its frameworks, and even in the practices of the institutions that adopt it (organizational culture, working methods, etc.).

It is worth noting that the concept of DQM in the context of documentation institutions is not very different from its concept in the business sector. This is because the differences recorded between quality management in documentation institutions and other sectors are not so much related to the concept itself, but rather to the focus, goals, and methodologies. While business institutions prioritize financial performance, focusing on cost management and profit generation, often using metrics such as Return on Investment (ROI) as a success indicator, libraries, according , to (Holt, 1996a),aim to enhance customer service, ensure their security and privacy, and meet community needs through high-quality services. They are often guided

by feedback from customer partners, and they strive to create social value and enhance community engagement, reflecting their commitment to social responsibility(Jorge-García-Reyes, 2022, p. 63). Therefore, the strategies for implementing quality management, as well as its tools, techniques, and frameworks, tend to differ between the two sectors.

Just like Total Quality Management (TQM), DQM in the context of documentation institutions, even if it retains the basic concept and common points—most notably the technical foundation of using digital technologies, employing modern tools, automating processes, and the general goal of improving quality, increasing efficiency, and achieving user satisfaction—will certainly differ in its sub-goals, areas of focus, and implementation strategies, depending on the institutional context in which it is applied

2.2 Benefits of Digital Quality Management

Experts hold varying perspectives on the specific benefits of DQM. After thorough research in the literature, we have been able to identify its key benefits (Aleksandrova et al., 2018, p. 21; Gao et al., 2024b, p. 194 197; Shaban et al., 2024, p. 1132; Vasiliev & Aleksandrova, 2020; Андреевич & Викторовна, 2022, p. 23 24):

_Improved Product Quality: By utilizing digital tools for real-time monitoring and control, DQM allows centralized control over the entire product lifecycle, from design to production and quality monitoring. This integration enhances efficiency, accuracy, and responsiveness, ultimately leading to higher product quality and better alignment with customer expectations. The integration of these digital tools with data analytics tools enables quick identification and resolution of quality issues, data-driven decision-making, and timely

adjustments and improvements to quality standards. This ensures consistency, reduces errors, and guarantees a high-quality product.

_**Improved Efficiency and Reduced Costs**: DQM enhances efficiency by collecting real-time data, detecting errors, streamlining processes, reducing human errors, and facilitating timely adjustments. It fosters collaboration between teams and various stakeholders, ultimately improving the overall operational effectiveness within the organization. By automating routine tasks and operational processes, DQM helps reduce operational costs. Additionally, real-time monitoring and data analysis help detect potential quality issues early, significantly reducing the likelihood of errors and saving time and costs associated with rework.

_**Supporting Digital Innovation**: Through improved data management and decision-making processes, DQM accelerates feedback loops and fosters a culture of continuous improvement, which are essential elements for innovation. DQM also helps organizations adapt to rapid technological advances. By leveraging data analytics and machine learning technologies, DQM plays a critical role in driving continuous innovation.

_**Enhanced Smart Decision-Making**: One of the key aspects of DQM is its ability to enhance data management capabilities. Digital systems facilitate the collection and analysis of vast amounts of data more efficiently, ensuring that data is managed and utilized accurately. This leads not only to well-informed, timely decisions but also to predictive and intelligent decision-making that supports a culture of continuous improvement and innovation.

_**Improved Communication and Effective Collaboration**: The use of digital technologies ensures better communication between different management levels, stakeholders, units, and among teams and employees, guaranteeing effective collaboration across the organization.

_Enhanced Organizational Development: DQM enhances organizational development through improved management approaches, effective communication, and continuous improvements to quality management systems. By integrating modern information technologies, it ensures data protection and compliance with international standards.

_Improved Employee Productivity and Competencies: DQM enables employees to acquire new skills through continuous training on information technology usage and the development of digital competencies.

_Enhancing Quality Management: Some studies(Luo et al., 2022) (Aleksandrova et al., 2018, p. 18 -21)have highlighted that By integrating modern technologies with traditional quality management practices, DQM reinvigorates quality management systems. While the automation of its processes saves time, reduces effort, and minimizes errors, supporting these systems with digital technologies and electronic quality management systems enhances operational intelligence. This boosts operational efficiency and effectiveness, fosters integration, and improves consistency, responsiveness, and overall quality management practices within organizations.

2.3Challenges of Implementing Digital Quality Management

Documentation institutions face numerous challenges when implementing DQM, and some of the most significant include(Elg et al., 2021; Gao et al., 2024a; Vasiliev & Aleksandrova, 2022):

A. Organizational Challenges: New management initiatives often face strong opposition, and this is particularly true when adopting DQM, which will encounter resistance from employees accustomed to traditional quality management practices. It is difficult for them to embrace new digital methods, especially if the organizational culture does not encourage the use of digital tools. This

could hinder the effectiveness of DQM initiatives. Additionally, the absence of a clear digital strategy is one of the major organizational barriers, as it leads to poor resource allocation and obstructs effective implementation.

B. Financial Challenges: Kovrigin and Vasiliev(2020, p. 333) emphasize that the high financial costs associated with adopting DQM are one of the main challenges that may hinder organizations from adopting this modern management approach. DQM requires substantial financial investments to integrate digital technologies, as well as significant budgets for training employees in new technologies and upgrading the technological infrastructure. This complicates the implementation process and impedes achieving the desired outcomes from adopting this management approach.

C. Technological Challenges: A robust technological infrastructure and the intensive use of digital technologies (such as employing basic, advanced, and integrated technologies, and electronic quality management systems) are fundamental to DQM and are among its most critical success factors. This large financial investment is itself a challenge, in addition to the challenge of keeping up with technological changes. In this context, Ziwei Gao and his colleagues(Gao et al., 2024a, p. 55) emphasize that DQM in organizations depends on complex information technology systems, including data collection, storage, analysis, and feedback. However, rapid technological advancement and continuous updates can lead to outdated and incompatible technology, which makes it harder to integrate systems and share data effectively.

D. Human Challenges: The skills gap is one of the most significant challenges facing this management approach. DQM requires professionals who possess advanced knowledge in both quality management and digital technologies. This dual expertise is essential for the effective application of DQM. Achieving this expertise requires training that demands considerable time and

resources. Additionally, the time needed for employees to adapt to new technologies can create an obstacle that prevents the successful implementation of DQM practices.

E. Data Security and Quality Challenges: Ziwei Gao and his colleagues point out that enhancing the overall utility of data is a core component of DQM Transitioning to this management approach often involves dealing with large amounts of data, which presents significant challenges related to data security and privacy. Furthermore, challenges related to processing vast amounts of data complicate the situation. Adding to the complexity is the challenge of ensuring data quality, from ensuring data accuracy and integrity to standardizing data across multiple platforms and addressing issues related to data analysis, precision, consistency, and security. All of these factors collectively pose significant challenges to the success of DQM. (Gao et al., 2024b, p. 111)

F. External Environmental Challenges: Uncertainty, instability, and continuous changes in the external environment—such as shifts in market demand, intense industry competition, policy changes, and regulations—are among the main challenges that affect the implementation and effectiveness of DQM.

It is also worth noting that, in addition to these general challenges, documentation institutions face their own unique challenges stemming from their nature and specificity. These include

_Resource Limitations: Although documentation institutions differ in size, available resources, and infrastructure, many suffer from deficiencies in human, technological, or financial resources—with financial limitations being the most impactful. This is affirmed by Holt, G.E. (1996), who states that "quality costs money, and regardless of the available resources, providing a higher-quality library service will always be more expensive than offering a lower-quality one(Holt, 1996, pp. 563–564). If this holds true for traditional quality

management practices, then the challenge becomes even more complex when it comes to adopting DQM.

_Expanding Goals: Documentation institutions focus on improving service quality to satisfy their users. Transitioning to DQM requires a focus on additional goals, such as enhancing the digital user experience, developing technological infrastructure, redesigning processes to align with digital requirements, strengthening cybersecurity, and developing employees' digital skills. Each of these goals presents new challenges.

_Legal and Regulatory Challenges: The absence of clear legislation to protect digital information and content in documentation institutions raises concerns about liability for violations of laws or regulations. Moreover, the lack of standardized guidelines on how to apply this management approach in these institutions constitutes a significant obstacle, complicating the transition to DQM.

_Data and Content Privacy: Documentation institutions handle sensitive information with historical and cultural value. Therefore, balancing the legal and regulatory requirements for data protection with the need to ensure data security and privacy, while also respecting fair access rights to knowledge resources, is a major challenge for DQM in these institutions.

3. Knowledge in Documentation Institutions: From Preservation to Industry

3.1 The Role of Documentation Institutions in the Knowledge Industry

Although documentation institutions—represented by libraries and information services—have been recognized as part of the information industry sector by early knowledge economy theorists such as Fritz Machlup(Machlup, 1962, p. 416) and Marc Porat(Porat, 2009), there remains a widespread belief that these institutions do not actively participate in the knowledge industry. Instead, they are often

perceived as merely providing and distributing information services. This perception is not only rooted in the traditional view of their role but is also due to the scarcity of literature that explores the concept of the knowledge industry within this sector. Additionally, the blurred boundaries between knowledge-based industries and other types of industries further complicate its classification. The association of the term "manufacturing" with tangible products has also sparked debates on whether it is appropriate to use this term for institutions primarily focused on user satisfaction and service quality, which are intangible assets.

However, the definition provided by Austrian-American economist Fritz Machlup offers a framework for understanding the role of documentation institutions in the knowledge industry. He explains that the knowledge industry "includes organizations that create or disseminate knowledge, while knowledge professions refer to individuals whose primary role is processing, creating, or transmitting knowledge—both of which are essential for economic activities that focus on the production and transfer of valuable knowledge."(Machlup, 1962, pp. 44–46)

Based on this perspective, documentation institutions play a critical role in gathering, organizing, and disseminating knowledge. They provide an environment for researchers and professionals to generate new knowledge, contributing to the conditions necessary for the production and transfer of valuable information. This makes them an integral part of the knowledge industry.

In 1996, Frank Lee and Hand Hass categorized 55 industrial activities into three groups:

a) _High-knowledge industries: which include sectors related to innovation and new technologies.

b) _Medium-knowledge industries: which are characterized by mass production and mature sectors such as the automotive and electrical products industries**.**

c) _Low-knowledge industries:which are typically labor-intensive sectors such as woodworking, furniture manufacturing, retail trade, and clothing.(Huggins & Izushi, 2007, p. 174)

This classification supports the idea that all industries are knowledge-based to some extent, though the level of knowledge intensity varies from one industry to another. It also reinforces the notion that documentation institutions, even if not considered high-knowledge industries, actively participate in knowledge industry and support all other industries by providing the necessary information and knowledge for innovation and development.

In alignment with Bernard et al.'s definition of the knowledge industry as "those industries that rely on knowledge in planning and executing their core activities, or where knowledge constitutes an essential component of their product and service offerings,"(Barnard, 1961, p. 366) documentation institutions can be seen as heavily reliant on knowledge in all aspects of their operations. Knowledge is also a fundamental part of the services they provide to their users.

Similarly, (Alonso-Amo et al., 1992) refer to the knowledge industry as the intellectual industry, defining it as a sector that utilizes vast amounts of knowledge derived from the intersection of science and technology in the post-industrial society. They emphasize processes such as reasoning methods and logical thinking in creating valuable knowledge products. This is precisely what librarians and archivists do when analyzing documents and information sources, identifying relationships between them, extracting key information, and presenting it to users in an organized manner while ensuring ease of access.

Based on the definitions above, documentation institutions play two crucial roles in the knowledge industry:

1. **As knowledge suppliers**, they provide essential resources for knowledge professionals and organizations, offering the information resources and data necessary for knowledge creation

2. **As knowledge creators**, they generate valuable knowledge with economic potential.

The **first role** is embodied in the transformation of libraries into digital platforms, which has significantly enhanced access to information. The integration of advanced technologies—such as metadata management and search algorithms—has led to improved information retrieval processes. This transformation has positioned libraries as central hubs for knowledge exchange, advocates of open access, and promoters of digital literacy. Consequently, librarians are increasingly seen as knowledge managers.(Talikoti, 2024, p. 594)

The **second role**, which involves shaping knowledge into a product with economic value, manifests in various ways, including: (Al-Rizzo, 2006, pp. 355–365)

- Selling knowledge as part of consultancy services.
- Developing conceptual frameworks as part of specialized expertise offered to external organizations.
- Designing training programs.
- Transforming knowledge into products such as knowledge databases and publications.

This transformation has led libraries and archives to evolve from mere repositories of knowledge into dynamic centers for knowledge creation(Гуралюк et al., 2020), management, and dissemination. Many documentation institutions now offer:

- Educational programs and training courses, such as online courses on research methods using AI tools.

- Workshops, such as academic writing and research methodology training.
- Development of digital educational content, including instructional videos on library usage.
- Consultancy services, such as advising on research methodologies.
- Knowledge licensing, allowing other organizations to utilize their intellectual assets.
- Collaborations with business and industrial sectors to develop knowledge-based products.

All these activities go beyond traditional services; they represent the transformation of knowledge into tangible and marketable intellectual assets, solidifying the role of documentation institutions in the knowledge industry.

3.2 Components and Elements of the Knowledge Industry

Hisham Ghassib(Ghassib, 2012, pp. 8–12) argues that the knowledge industry, like any other industry, can be analyzed and understood in terms of its core components, which include: production sites, such as universities, research institutes, and research and development (R&D) units within corporations; knowledge producers, primarily highly trained scientists supported by administrators, engineers, and technicians; production tools, both tangible (e.g., laboratories, equipment) and intellectual (e.g., mathematical techniques, logical methodologies, philosophical concepts); raw materials, which consist of knowledge itself and the subjects of knowledge that drive its evolution; production methods, which are inherently creative, dynamic, and constantly evolving; and knowledge products, which differ from industrial products in that they are evaluated by the scientific community and are often unpredictable in terms of outcomes.

In this context, Fritz Machlup(1962, pp. 29–30) categorizes knowledge as either a final product or an essential input for other goods and services. Knowledge as a final product is further divided into consumption-based knowledge (e.g., entertainment sectors) and investment-based knowledge (e.g., education and scientific research outputs).

These components closely align with the foundational elements identified by F. Alonso-Amo and his colleagues(Alonso-Amo et al., 1992, pp. 147–150). They classify the knowledge industry into several key categories. Raw materials include data, information, and knowledge. Knowledge creators, such as researchers and scientists, generate and refine knowledge. End users, like professionals (e.g., lawyers), apply knowledge in their daily work and gain expertise. Distributors, such as educators, facilitate the transfer of knowledge. Lastly, knowledge engineers oversee the knowledge manufacturing process, using scientific facts to develop intellectual products systematically through science and technology, rather than relying on traditional artistic and creative human efforts.

The knowledge industry also encompasses foundational engineering disciplines (e.g., knowledge engineering, software engineering, and various technologies) and production processes, which include methodologies, techniques, procedures, and tools for knowledge creation. These activities involve knowledge extraction, representation, and application to solve problems.

The outcome is explicit, well-structured, high-quality knowledge that is packaged as a marketable product, much like any other commercial good.

3.3 Challenges of the Knowledge Industry in Documentation Institutions

The knowledge industry requires "a robust industrial foundation that includes highly skilled professionals, strong physical and digital infrastructure, and a regulatory framework conducive to commercial operations".(Anan, 2018, p. 215) Based on these requirements, the key challenges facing the knowledge industry in documentation institutions can be identified as follows:

A. Organizational Challenges: As previously discussed, the knowledge industry requires a flexible organizational framework compatible with commercial practices and new work methods that promote innovation. This need often clashes with the traditional structures and systems adopted by documentation institutions, as well as with their typical areas of focus. A lack of understanding and awareness regarding the role of the knowledge industry in achieving strategic objectives often leads leadership to prioritize routine tasks over creative activities. Furthermore, many library professionals are unfamiliar with the concept of the knowledge industry, and a considerable number oppose the idea of commodifying knowledge(bencharef, 2024), which constitutes a major barrier to change. This resistance to change remains one of the most significant obstacles hindering the adoption and advancement of the knowledge industry within these institutions.

B. Human Resource Challenges: The knowledge industry requires highly creative professionals with the ability to leverage technology and apply their expertise to create innovative knowledge products with economic value. These professionals must "possess key competencies such as intelligence, self-management, a strong capacity for learning, independence, and creativity. They should also demonstrate a commitment to knowledge acquisition, the ability to apply expertise effectively, and a willingness to share insights with others to achieve organizational goals"(Bouziani & Dooley, 2019, p. 801) . The lack of such skilled professionals within documentation institutions is a major barrier preventing them from transforming into

EISSN: 2602-781X———ISSN: 2253-0347

knowledge-producing entities. It is worth noting that the shortage of specialized knowledge industry experts and the challenges associated with training them are global concerns, not limited to specific sectors or countries. Alonso-Amoand his colleagues(Alonso-Amo et al., 1992, p. 147) argue that the solution is not to increase the number of specialized knowledge industry professionals, as this would raise the costs of developing knowledge products. Instead, improving productivity through technological and intellectual advancements should be the focus.

C. Financial and Physical Infrastructure Challenges: The knowledge industry requires substantial financial investment, which documentation institutions often struggle to secure due to limited funding and resource constraints. This financial limitation affects their ability to: develop the necessary infrastructure, acquire essential and advanced technologies, and invest in knowledge industry programs and intellectual property development.

D.Technological Challenges: A sophisticated technological infrastructure is essential for the knowledge industry(Luo et al., 2022). The use of outdated technology leads to incompatibility between information systems and knowledge industry requirements, hindering collaboration and data exchange among teams. It also presents challenges in ensuring information security and data protection. This challenge is further compounded by the rapid pace of technological advancements, which often outstrip the financial and technical capabilities of documentation institutions. The inability to keep up with these technological changes exacerbates financial, human resource, and organizational challenges. The obsolescence of technology remains one of the biggest barriers to the effective implementation of knowledge industry processes and the development of high-value knowledge products.

E. Legal and Ethical Challenges: Since the primary goal of the knowledge industry is to generate financial revenue through the sale of knowledge products and services, it involves all aspects of commerce, including production, marketing, sales, and customer service. This necessitates compliance with commercial laws, which documentation institutions may struggle with, as they are not originally commercial entities. In addition to commercial regulations, documentation institutions face legal and ethical challenges, including the absence of clear legal frameworks to protect digital content, privacy, confidentiality, and intellectual property rights, as well as ethical concerns related to transparency, accountability, credibility, and fair access to knowledge. (bencharef, 2024)

F. Economic Barriers: In a related context, economist Fritz Machlup(1962, p. 44) pointed out numerous inherent challenges in the knowledge industry that are difficult to overcome. Among them is the difficulty of conducting statistical analysis due to the intangible nature of this industry. Unlike traditional sectors, there is no measurable physical output, and it's nearly impossible to separate output metrics from input measures, as knowledge development is an ongoing and evolving process. Additionally, most knowledge industry services are distributed for free or at prices below cost, often subsidized by governments, philanthropists, or advertisers. As a result, consumer-based evaluations—common in other industries—are largely absent, making it difficult to assess sales or pricing accurately. Consequently, determining the economic impact of increased spending on the knowledge industry remains highly challenging.

Based on the discussion above, it becomes clear that the challenges of the knowledge industry within documentation institutions are numerous and deeply intertwined. Addressing them will require comprehensive solutions, including the development of a robust infrastructure supported by advanced technologies, a workforce with high-level knowledge skills, sustainable financial resources, a

regulatory environment conducive to commercial knowledge activities, broad stakeholder engagement (including researchers, business leaders, and decision-makers), and a sound administrative approach that integrates strategic planning with efficient resource management. This is essential to overcoming these challenges and ensuring the fulfillment of institutional goals.

4. The Role of Digital Quality Management in Developing the Knowledge Industry in Documentation Institutions

4.1 Digital Quality Management and Addressing the Challenges of the Knowledge Industry in Documentation Institutions

DQM can contribute effectively to fulfilling the fundamental for developing the knowledge industry in documentation institutions by providing a structured framework that helps overcome obstacles and address challenges, as follows:

A. Addressing Organizational Challenges: As mentioned earlier, modifying management mechanisms and adopting digital thinking are among the key foundations for successfully implementing this management approach. Therefore, adopting DQM will require documentation institutions to adjust their management systems to align with the requirements of this technology-driven approach. This adjustment necessitates establishing flexible organizational structures that enhance collaboration across different departments. This measure significantly contributes to knowledge exchange and development within the institution, which is crucial in the context of the knowledge industry.

- Additionally, fostering digital thinking when adopting this approach will help reduce resistance to change and promote a culture that supports knowledge industry.
- Furthermore, emphasizing the utilization value of data—one of the key principles of DQM—will increase the institution's

commitment to providing accurate data and conducting in-depth analyses on performance and available knowledge. This, in turn, will help in setting clear objectives and strategic visions for knowledge industry, supporting effective strategic planning and enabling informed decision-making for transitioning into the knowledge industry.

B. Addressing Financial Challenges: The financial effect of DQM is indirect. Better data quality and more efficient processes (Sections 4.2-A and 4.2-B) lower the cost of each knowledge product, while higher product quality and faster feedback (Sections 4.2-C and 4.2-D) make products fit user needs more closely. This value can become economic return through cost savings, revenue from marketable products such as training programs, consultancy, and knowledge databases (Al-Rizzo, 2006, pp. 355–365), and a stronger case for funding backed by documented performance. Since knowledge services are often distributed free or below cost (Machlup, 1962, p. 44), the return will often take the form of savings or sustained funding rather than profit. This chain remains a theoretical proposition that has not been tested empirically.

C. Addressing Technological Infrastructure Challenges: DQM leverages technology strategically to improve an institution's quality management capabilities in the digital environment. Therefore, institutions adopting DQM must continuously update their tools and technological infrastructure to ensure the implementation of advanced digital systems that offer several benefits, including: (Ibrahim, 2019, pp. 164–168)

- Flexibility, allowing documentation institutions to adapt easily to market changes and requirements.
- Risk management capabilities, enabling institutions to effectively identify and mitigate potential risks.

EISSN: 2602-781X——————ISSN: 2253-0347

- Integration with various internal systems, facilitating seamless information flow and easy access to knowledge.
- Robust security measures, ensuring data protection and preventing cyber threats or unauthorized access.

These features collectively establish a strong foundation that enhances trust in the use of modern technology in knowledge-related processes while ensuring high-quality knowledge products.

D. Addressing Human Resource Challenges: DQM supports digital capacity building through electronic training programs designed to enhance creative and digital skills and promote continuous learning. This reduces employees' concerns about technology, increases their technical readiness, and helps them adapt more effectively to digital transformation.

Additionally, DQM systems facilitate performance monitoring and feedback, allowing institutions to improve training programs (Walton, 2018). This enables information professionals to refine their skills in knowledge industry to meet market needs and effectively utilize digital tools in the process. Furthermore, this management approach fosters a collaborative and innovative work environment, encouraging creativity and innovation—which are critical for developing valuable and economically viable knowledge products.

Based on the elements reviewed above, we can conclude that DQM serves as an effective tool for addressing the key organizational, financial, technological, and human challenges facing the knowledge industry in documentation institutions. Additionally, it may help institutions enhance their competitiveness and sustainability by improving adaptability to technological advancements, fostering a culture of continuous improvement, minimizing waste, and increasing

efficiency. This, in turn, can allow institutions to allocate the necessary resources to sustain the knowledge industry over time..

4.2 Contributions of Digital Quality Management in the Stages of Knowledge industry in Documentation Institutions

The role of DQM in knowledge industry is reflected in its contributions to various stages of the process, including:

A. Ensuring the Quality of Knowledge Inputs (Information Resources and Data):

Data and information serve as the fundamental building blocks of knowledge industry. Ensuring their quality directly impacts the accuracy, reliability, and overall quality of knowledge-based products. Since DQM primarily aims to enhance the usability of data, it plays a vital role in ensuring the quality of knowledge as the core input of the knowledge industry

By utilizing information technologies to automate and streamline data collection, storage, and analysis, DQM facilitates the management of big data (Васильев & Александрова, 2024) , which is crucial in Knowledge-based industry. Automating data collection minimizes human errors, while DQM systems (Vasiliev & Aleksandrova, 2020) enforce strict data auditing and cleansing procedures, increasing reliability and accuracy. Furthermore, advanced digital tools for data analysis enable institutions to extract valuable insights efficiently. All these aspects confirm the critical role of DQM in ensuring the integrity and quality of knowledge as a core input of the knowledge industry.

B. Enhancing Process Efficiency and Effectiveness:

An advanced and innovative knowledge industry relies on optimized processes that aim to achieve the highest levels of quality and excellence. In this context, Digital Quality Management (DQM) empowers documentation institutions to enhance the efficiency and effectiveness of various knowledge industry operations, from the

acquisition of knowledge inputs to their transformation to its transformation into marketable and economically valuable knowledge products.

This is achieved through several interconnected interventions:

- **Process automation** is a central element, as DQM improves efficiency and accuracy by reducing human error, eliminating slow and error-prone tasks, and optimizing workflow sequences.
- **Streamlining operations** by removing redundant and unnecessary steps makes processes more transparent and easier to manage.
- **Optimizing workflow sequencing** allows for better detection of failures and inefficiencies, helping institutions remove bottlenecks at various stages of the knowledge industry lifecycle.
- **Standardizing procedures** contributes to improved operational performance and facilitates smooth integration between knowledge production and management systems.

By integrating modern technologies into quality management practices, DQM strengthens control over knowledge production processes, ensuring that knowledge industry operations remain streamlined, high-performing, and aligned with strategic goals. (Кудрявцева et al., 2022, p. 39 -40)

C. Ensuring High-Quality Knowledge Products:

By utilizing real-time monitoring and control tools, DQM allows centralized oversight of the entire product lifecycle, from design to creation and quality control. This integration enhances efficiency, precision, and responsiveness, ultimately leading to higher product quality and better alignment with customer expectations.

Additionally, integrating real-time monitoring with data analytics enables institutions to detect and resolve quality issues more quickly (Aleksandrova et al., 2018) This ensures that documentation institutions can develop high-quality knowledge products by implementing quality control measures at every stage of creation, from initial design to final output.

Furthermore, data-driven decision-making capabilities enable timely modifications and improvements to quality standards (Gao et al., 2024b), which may enhance the value of knowledge-based products to users. By ensuring that knowledge products are of high quality and aligned with user needs, DQM may increase their value and, through the chain outlined in Section 4.1-B, support the financial sustainability of documentation institutions.

D. Enhancing and Supporting Innovation:

DQM plays a critical role in enabling documentation institutions to create innovative knowledge products. By collecting and analyzing large volumes of data, DQM provides institutions with valuable insights into market needs, allowing them to make informed, predictive decisions. These insights guide the development of more advanced, creative products that better align with user expectations. (Васильев & Александрова, 2024a)

To achieve this, DQM contributes through several key mechanisms:

- Accelerating feedback and improvement cycles reduces product development time.
- Early user feedback allows for continuous refinement and enhancement of knowledge products.
- Creating interactive environments fosters collective innovation and enhances collaborative knowledge sharing.

Thus, DQM is far more than just a modern administrative approach adopted to improve institutional performance. It stands as a powerful enabler of transformation, serving as a fundamental pillar in turning documentation institutions into knowledge creation centers and advancing their knowledge industry. With the implementation of DQM, libraries and archives are empowered to effectively address the challenges associated with this transformation. Its influence extends beyond merely improving operational processes—it supports the delivery of high-quality knowledge products and services, may increase their value, and can enhance institutional competitiveness within the knowledge economy. This positions DQM as a strategic cornerstone in building a promising future for the knowledge industry in documentation institutions.

However, in order to maximize the benefits of DQM, documentation institutions must adopt it comprehensively and systematically, following the integrated framework proposed below.

4.3 Proposed Framework

The proposed framework was built by conceptually integrating the preceding theoretical analysis. It rests on the first scenario in Cots (2018, p. 607), that of organizations undergoing or having completed digital transformation, and sets out the minimum requirements for implementing DQM in such institutions, to be expanded according to their context and resources. Institutions without a clear digital vision should first integrate DQM into their broader digital strategy.

The framework has two strategic pathways. The first, implementing DQM within documentation institutions, draws on the dimensions that define DQM (digital thinking, digital technology, management mechanisms, and data applications; Gao et al., 2024a, p. 55) and on the challenges discussed in Section 2.3. The second, using

DQM to develop the knowledge industry, draws on Sections 3.1, 3.2, 4.1, and 4.2 (Machlup, 1962; Alonso-Amo et al., 1992; Ghassib, 2012) and and on the knowledge product management life cycle of design, creation, and quality monitoring (Al-Rizzo, 2006), which this study extends with planning, marketing, and sustainability to cover the economic dimension of knowledge products. Each pathway is detailed below.

First Pathway: Implementing Digital Quality Management in Documentation Institutions

A. Preliminary Stage (Zero Phase): Consistent with the framework's premise (Cots, 2018, p. 607) and with the dimensions and challenges on which this pathway draws (Gao et al., 2024a, p. 55; Section 2.3; Elg et al., 2021; Vasiliev & Aleksandrova, 2022), this stage establishes the institution's starting point through four steps:

- Analyzing its current operational landscape and confirming that it has a digital transformation plan or vision.
- Assessing its use of technology for quality enhancement (quality maturity evaluation);
- Analyzing its digital infrastructure and existing processes to identify the digital technologies required;
- Evaluating the digital skills, expertise, and capabilities of institutional staff in quality management and technology utilization, along with their awareness of DQM's significance and their readiness for change.
- **Performance and readiness indicators:** Two sets of indicators are used at this stage. The first comprises *readiness indicators*, which correspond to the four steps above and assess the institution's capacity to adopt DQM: (1) the existence and degree of completeness of a digital transformation plan or vision; (2) the quality maturity level, rated against an adopted maturity scale; (3) the extent to which the digital infrastructure and existing processes cover the

required technologies (e.g., the share of processes already digitized); and (4) the digital skills gap among staff, together with their awareness of DQM's significance and their readiness for change, measured through a survey. The second set comprises *performance indicators*. Baseline values are recorded for six of them, forming an internal benchmark against which later progress is measured: error rate, service delivery time, data quality, user satisfaction, digital usage, and cost. These six are this study's proposal, derived from the benefits attributed to DQM in Sections 2.2 and 4.2 (fewer human errors, faster cycles, data accuracy and reliability, user satisfaction, and lower costs) and from the digital objectives in Section 2.3. Where historical records are unavailable for some of them, their baseline values are collected or estimated during this stage.

B. Preparation Stage: building on the starting point established in the preliminary stage, this stage is organized around the four dimensions in the definition of DQM (Gao et al., 2024a, p. 55): applying digital technology (infrastructure upgrading and the choice between a customized and a ready-made system), fostering digital thinking (organizational culture and digital capabilities), adjusting the management mechanism (administrative and workflow restructuring), and developing data applications (objectives, KPIs, and digital quality standards). Strategic planning responds to the absence of a clear digital strategy identified in Section 2.3, the feasibility assessment responds to the financial barriers reported by Kovrigin and Vasiliev (2020, p. 333), and the infrastructure requirements reflect the system features discussed in Section 4.1 (Ibrahim, 2019, pp. 164–168). The stage proceeds as follows:

- **Strategic planning:** setting clear, measurable objectives and a detailed implementation plan that defines the required policies, mechanisms, activities, and resources, the key performance indicators (KPIs), and a timeline for execution.

- **Digital infrastructure:** upgrading IT systems and communication networks, and assessing the feasibility of either developing a customized DQM system for the institution or acquiring a ready-made solution.
- **Culture and capabilities:** fostering a digital-friendly organizational culture and building employees' digital capabilities through training that enhances technical skills and preparedness for DQM implementation.
- **Administrative mechanisms and workflows:** aligning them with DQM requirements by restructuring the organizational hierarchy, updating workflow procedures, redesigning workflow processes and quality assurance protocols, defining digital quality standards and ensuring compliance, establishing specialized task forces for DQM implementation, clearly assigning roles and responsibilities to all employees in quality management, and recruiting quality management and digital transformation experts.
- **Performance indicators**: For each indicator, a target value, measurement method, data-collection frequency, and responsible team are defined, in line with the data applications dimension (Gao et al., 2024a, p. 55). Cost is additionally tracked as the difference between planned and actual implementation budgets, which links the cost indicator to the financial barriers noted above (Kovrigin & Vasiliev, 2020, p. 333). The digital usage indicator follows the system features in Section 4.1

C. Implementation Stage: Following the preparation stage, this stage rests on the digital technology and data applications dimensions of DQM (Gao et al., 2024a, p. 55), on the integration of DQM systems with internal systems (Ibrahim, 2019, pp. 164–168), and on the strengthening of quality management systems through digital technologies (Luo et al., 2022; Aleksandrova et al., 2018, pp. 18–21). It executes the plan through:

- Deploying the acquired or developed digital technologies and integrating DQM systems with the institution's existing systems.
- Training employees and providing ongoing technical support to address potential challenges.
- Conducting periodic system performance reviews to identify weaknesses and make necessary adjustments.
- Monitoring operational processes and evaluating the impact of newly implemented systems on overall quality assurance.
- Developing continuous improvement strategies to refine the system over time.
- Performance indicators: Two sets of indicators are monitored at the review intervals set in the preparation stage. The first comprises process indicators, which track the progress of implementation and correspond to the stage's steps: the percentage of plan tasks completed against the timeline; the share of DQM systems actually integrated with internal systems; the proportion of employees who completed training, together with the number of technical support requests and their average resolution time; the number of periodic system reviews conducted and of adjustments implemented as a result; and the number of continuous improvement initiatives proposed and implemented. The second comprises outcome indicators, namely error rate, service delivery time, data quality, digital usage, and cost, which are compared with the baseline and target values. Internal users' satisfaction with and acceptance of the new systems may also be monitored at this stage, as an early signal that supports the training and support step, whereas the satisfaction of external users is deferred to the later stage, once the effects of the new systems have materialized.

D. Development Stage: After successfully implementing the new DQM systems and achieving the defined objectives, institutions can consider introducing additional tools to further enhance quality

management practices and drive continuous improvement. This stage draws on the continuous improvement that DQM is expected to deliver (Section 2.2; Aleksandrova et al., 2018, p. 21) and on the risk of technological obsolescence (Section 2.3-C; Gao et al., 2024a, p. 55).

Performance indicators: The objectives are considered achieved when the indicators reach their target values. From that point, three sets of indicators are monitored. Sustainability indicators show whether the six indicators keep their target values across successive measurement cycles and how much they improve beyond them. Development indicators track the number of additional tools introduced and implemented, the new objectives set and achieved, and the recalibrations of baseline and target values. Obsolescence indicators cover the frequency with which the technologies in use are reviewed against available alternatives, the share of technical components updated or replaced as planned, and the extent to which staff skills are updated. Baselines are recalibrated accordingly, consistent with the continuous improvement and obsolescence points above .

Second Pathway: Digital Quality Management Interventions for Developing Knowledge Products in Documentation Institutions

After successfully adopting DQM, documentation institutions can now leverage the benefits of this administrative approach to enhance their knowledge industry through the following steps:

A. Knowledge Product Planning Stage

Planning decides which knowledge product will be made, from which core input , by whom, at what cost, and for whom. In documentation institutions it must deal with the features of the knowledge industry identified in Section 3: knowledge as the raw material (Alonso-Amo et al., 1992), the unpredictable outcomes of knowledge products (Ghassib, 2012), the absence of consumer-based

evaluation (Machlup, 1962, p. 44), and limited financial resources (Section 3.3-C). DQM responds by applying its contribution to data quality and data-driven decision-making (Sections 2.2 and 4.2-A; Gao et al., 2024b). Its protection step addresses the data security challenge discussed in Section 2.3-E. DQM supports planning through the following activities:

- Market Needs Analysis: Using digital technologies, institutions can collect, organize, and analyze data on user preferences and historical knowledge product trends. This helps identify success factors, with DQM systems ensuring data accuracy and reliability.
- Defining the Target Knowledge Product: AI-based predictive models assist in selecting the most suitable knowledge product(s). DQM establishes quality standards and performance indicators, which are then used to develop detailed product specifications (content, design, technical features). These specifications are digitally documented, and predictive models estimate the resources and costs required for creating the product. DQM ensures the accuracy and reliability of the data used in these estimates.
- Protection and Accessibility: Cloud storage secures all planning data, while cybersecurity protocols safeguard information from unauthorized access.
- Work Plan Development: DQM creates a detailed action plan for creating the knowledge product, outlining tasks, responsibilities, and timelines while ensuring systematic documentation of procedures.
- Digital Planning & Scheduling: Using digital scheduling tools, DQM assigns timeframes for each creation phase.
- Stakeholder Information Access: DQM establishes mechanisms to ensure that all relevant stakeholders (users, employees, partners) have access to the necessary information regarding creation processes and the knowledge product, tailored to their roles.

• **Performance indicators**: Because the outputs of knowledge production are difficult to measure directly (Machlup, 1962, p. 44), the indicators at this stage focus on process and data: data quality (the share of market and user data meeting accuracy, completeness, and consistency criteria; Gao et al., 2024b), planning time (from identifying the need to approving the specifications), and cost variance (the gap between estimated and actual cost).

B. Design & Prototyping Stage

Knowledge products are judged by the scientific community and their outcomes are hard to predict (Ghassib, 2012), so flaws should surface before production. DQM therefore builds testing and feedback into the design itself. It applies the accelerated feedback loops that support innovation (Section 4.2-D) and the quality control that begins at the design phase (Section 4.2-C; Aleksandrova et al., 2018).

• Selecting Digital Design Tools: Based on product specifications and characteristics, institutions choose digital design programs, modeling tools, and collaborative design platforms that offer usability, efficiency, integration capabilities, and real-time collaboration.

• Prototype Review: DQM automatically verifies prototypes for compliance with technical specifications and predefined quality standards using automated compliance systems.

• User Experience Simulation & Testing: Using feedback integration, AI-driven simulation programs, or digital twin technology, DQM enables institutions to test and refine product designs. Digital analysis tools provide insights into user interactions, identifying areas for improvement and necessary modifications to ensure high-quality knowledge products.

• Employee Training: Based on feedback from the design phase, DQM facilitates employee training programs to enhance technical skills and familiarize staff with the new product specifications.

•**Performance indicators**: specification compliance (the share of prototypes passing review at the first attempt), design iteration time (from the first prototype to approval), and user satisfaction with the tested prototype.

C. Production Stage

Knowledge creation relies on methodologies, techniques, and procedures for extracting, representing, and applying knowledge, overseen by knowledge engineers (Alonso-Amo et al., 1992, pp. 147–150). This stage covers documentation institutions' role as knowledge creators (Section 3.1). DQM controls these processes through the efficiency and quality assurance contributions in Sections 2.2, 4.2-B, and 4.2-C (Aleksandrova et al., 2018; Кудрявцева et al., 2022).

DQM interventions at this stage are numerous, including the following:

• **Automated Workflow Monitoring**: Digital documentation of work procedures and production processes enables traceability, helping institutions reduce variation and ensure compliance with global quality standards. Automated workflow management reduces human errors and speeds up production cycles, allowing quality managers to oversee each production stage.

• **Automated Quality Control**: Using sensors and advanced monitoring systems, DQM collects real-time production data, extracting valuable insights through data analysis technologies.

• **Automated Quality Assurance**: Robotic systems and automated inspection technologies detect deviations from quality standards. DQM implements corrective measures, predicts potential issues, and improves processes through machine learning algorithms.

•**Automated Employee Performance Monitoring**: A real-time digital monitoring system assesses employee performance using data analytics to identify areas for improvement. Instant feedback helps employees enhance their skills and productivity, while DQM determines necessary training programs.

•**Performance indicators**: deviation rate (outputs departing from quality standards), creation cycle time, and rework rate.

D. Marketing Stage Knowledge services are often distributed free or below cost, so consumer-based evaluation is largely absent (Machlup, 1962, p. 44). Marketing a knowledge product therefore needs direct data on audiences and channels. Commodifying knowledge also meets ethical resistance in documentation institutions (bencharef, 2024) and calls for compliance with commercial law (Section 3.3-E). The literature reviewed here does not address DQM in marketing specifically, so this stage rests on its general data-driven contributions (Section 4.2).

DQM enables the marketing department to:

• Set precise marketing strategy objectives through data-driven planning, ensuring a clear understanding of target audiences, their preferences, and the most effective distribution channels.

• Ensure high-quality marketing campaigns by using automated performance monitoring tools to track campaign effectiveness in real time, allowing for immediate interventions and adjustments to maximize impact.

• Optimize marketing channels by evaluating different distribution methods to identify the most effective options for the target audience.

• Enforce quality standards for marketing processes, ensuring consistent delivery, performance evaluation, and continuous optimization through data analysis and real-time user feedback.

•**Performance indicators**: target audience reach, conversion rate per channel, and compliance of marketing processes with quality standards

E. Sustainability Development Stage: Knowledge development is continuous and evolving, and its economic impact is hard to assess (Machlup, 1962, p. 44). DQM therefore keeps evaluating the product after release, and the product has to stay available and effective without depleting resources (Section 4.1). DQM supports this through its continuous improvement principle (Section 2.2) and its digital collection and analysis of user feedback and performance data (Gao et al., 2024b).

DQM plays a pivotal role in this stage through:

• Evaluating Knowledge Product Performance**:** DQM continues to monitor the performance of the knowledge product after its release into the market by maintaining continuous quality monitoring and conducting periodic audits to ensure the product's compliance with established standards and requirements. DQM also ensures the provision of regular reports and detailed analyses about the product's performance, supplying relevant departments with this information to make informed decisions.

• Managing User Feedback Using Digital Platforms: DQM is responsible for collecting user feedback through digital platforms and analyzing this feedback to identify issues and opportunities for improving knowledge products and better meeting user needs.

• Continuous Updates and Development: Based on analysis data and user feedback, DQM provides recommendations for new features that help improve the product and establish new standards to enhance its overall performance and maintain quality. DQM also oversees the implementation of any modifications or updates, continuously ensuring that the product remains available, effective, and aligned

with the latest global standards while meeting future user expectations without depleting resources.

• Reinitiating the Cycle of Interventions Across the Knowledge industry Stages: As a result, the cycle of DQM interventions starts over, ensuring the continuous development and improvement of the knowledge industry process.

•Performance indicators: user satisfaction, update response time (from feedback to implementation), and audit compliance rate.

All these assessment indicators have been formulated as proposals derived from the theoretical framework and recognised international quality standards; consequently, each institution has the sole authority to adapt and define them in accordance with its own requirements.

• 4. CONCLUSION

Drawing on a theoretical and conceptual approach based on an analysis of the relevant literature, this study examined how Digital Quality Management (DQM) can contribute to the development of the knowledge industry in documentation institutions. It reached the following findings:

•DQM is not limited to introducing digital tools into traditional quality practices; rather, it represents a qualitative transformation in the concepts, philosophy, frameworks, and areas of focus of quality management.

•The challenges facing the knowledge industry in documentation institutions (organizational, human, financial, technological, legal, and economic) overlap considerably with the challenges of implementing DQM, which may constrain its adoption. Nevertheless, DQM can help address the organizational, financial, technological, and human challenges through flexible structures, digital thinking, improved process efficiency, and continuous capacity

EISSN: 2602-781X———ISSN: 2253-0347

building, whereas the legal and economic challenges lie largely beyond its direct reach.

•DQM can contribute across the stages of the knowledge industry, from securing the quality of the raw material to fostering innovation. This contribution is mediated: DQM improves data quality and process efficiency, which raises the quality of knowledge products and supports their alignment with user and market needs, thereby creating the potential for economic value. DQM can therefore be regarded as a strategic mechanism for transforming documentation institutions from custodians of documents into centers of the knowledge industry.

•The study's main contribution is an integrated conceptual framework with two complementary pathways: the first for implementing DQM within the institution (the preliminary, preparation, implementation, and development stages), and the second for applying it across the stages of knowledge product development (planning, design and prototyping, production, marketing, and sustainability).

Recommendations

In light of these findings, the study recommends the following:

•Integrating DQM into a comprehensive digital transformation strategy grounded in a structured framework, and investing in the technology and knowledge it requires;

•Giving priority to digital infrastructure as the cornerstone of DQM and the foundation for developing the knowledge industry;

•Developing specialized training programs on DQM and the knowledge industry, which are themselves knowledge products that institutions can offer; and

•Adopting the requirements set out in the proposed framework as the minimum baseline for implementing DQM, and progressively renewing and developing the adopted practices and technical tools,

according to each institution's capacities and context, toward advanced levels.

Limitations of the Study

This study was confined to documentation institutions. It adopted a theoretical and conceptual approach based on an analysis of the relevant literature, without primary field data. The proposed framework has not been empirically tested or subjected to expert review, and the relationship it describes between DQM and economic value remains theoretical. The framework's generalizability therefore remains to be verified in future research.

Directions for Future Research

Future studies are encouraged to validate the framework empirically through expert review (e.g., the Delphi method), case studies in libraries and archives, or a pilot implementation supported by measurable performance indicators. They may also examine the mediated relationship between DQM, product quality, and economic value, and explore how the legal and economic challenges identified here can be addressed.

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