

# Leveraging AI for Efficient Knowledge Management in NRENs

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**Abstract**—National Research and Education Networks are crucial in advancing education and research by providing specialized internet services and fostering collaboration among institutions. However, NRENs face unique challenges in managing and disseminating knowledge effectively. This literature review explores the potential of artificial intelligence powered knowledge management systems to enhance operational efficiency in NRENs. The review synthesizes current research on AI applications in knowledge management, examines the specific needs of NRENs, and identifies gaps in existing literature. Key areas discussed include AI-driven content creation, information retrieval, collaborative tools, and decision support systems tailored for NREN environments. The review also addresses challenges such as data privacy, integration with existing infrastructure, and the need for human oversight. By analyzing the intersection of AI, knowledge management, and NREN operations, this study aims to provide a foundation for future research and practical implementations that can significantly improve knowledge accessibility and operational efficiency in NRENs.

**Index Terms**—Artificial Intelligence, Knowledge Management, National Research and Education Networks, Operational Efficiency, Information Retrieval, Collaborative Tools, Decision Support Systems

## I. INTRODUCTION

National Research and Education Networks (NRENs) serve as the backbone of academic and research connectivity, providing specialized internet services and fostering collaboration among educational institutions. As knowledge-intensive organizations, NRENs face unique challenges in managing vast amounts of information, ranging from technical documentation to administrative guidelines and research outputs. The effective management and dissemination of this knowledge are crucial for maintaining operational efficiency and supporting the broader academic community. In recent years, artificial intelligence (AI) has emerged as a transformative force in knowledge management (KM), offering new possibilities for automating processes, enhancing information retrieval, and generating insights [1] [2]. While the integration of AI in KM

systems has been extensively studied in corporate settings, there is a notable gap in research specifically addressing the unique needs and challenges of NRENs. This literature review aims to bridge this gap by exploring how AI-powered knowledge management systems can be leveraged to enhance operational efficiency in NRENs. By synthesizing current research on AI applications in KM and examining the specific context of NRENs, this review seeks to identify key opportunities, challenges, and best practices for implementing AI-driven KM solutions in NREN environments. The importance of this review lies in its potential to inform future research and practical implementations that can significantly improve knowledge accessibility and operational efficiency in NRENs. As these networks continue to play a critical role in advancing education and research, optimizing their knowledge management processes becomes increasingly vital. AI-powered solutions offer promising avenues for addressing longstanding challenges in information organization, retrieval, and utilization within NRENs. This review will examine several key areas, including:

- The current state of knowledge management in NRENs and their specific challenges
- AI applications in knowledge management, with a focus on relevance to NREN operations
- The potential impact of AI-powered KM systems on NREN efficiency and effectiveness
- Challenges and considerations in implementing AI-driven KM solutions in NREN environments
- Future directions and research opportunities in this domain

This review provides a comprehensive overview of these topics, aiming to lay the groundwork for innovative approaches to knowledge management in NRENs. This will ultimately help them better serve the academic and research communities they support.

## II. CURRENT STATE OF KNOWLEDGE MANAGEMENT IN NRENS

National Research and Education Networks (NRENs) operate in a unique position within the academic and research landscape, serving as both service providers and collaborative platforms for their member institutions [3]. This dual role creates distinct knowledge management challenges that differ from those faced by traditional businesses or educational institutions. NRENs manage a diverse range of knowledge assets, including:

- Technical documentation for network infrastructure and services
- Administrative guidelines and policies
- Training materials for staff and member institutions
- Research outputs and collaborative project information
- Best practices and lessons learned from network operations

The effective management of these knowledge assets is crucial for maintaining operational efficiency, supporting member institutions, and driving innovation in research and education networking [4]. However, NRENs face several challenges in their knowledge management efforts:

- 1) **Rapid technological changes:** The fast-paced evolution of networking technologies requires constant updating of technical knowledge and documentation [5].
- 2) **Geographically dispersed teams:** Many NRENs operate across large regions or even entire countries, making knowledge sharing and collaboration more complex [6].
- 3) **Diverse stakeholder needs:** NRENs must cater to a wide range of users, from technical staff to researchers and administrators, each with different information requirements [3].
- 4) **Limited resources:** As non-profit organizations, NRENs often operate with constrained budgets and staffing, making comprehensive knowledge management initiatives challenging [7].
- 5) **Balancing openness and security:** NRENs must navigate the tension between openly sharing knowledge and protecting sensitive network information [8].

These challenges highlight the need for innovative approaches to knowledge management in NRENs, particularly solutions that can enhance efficiency and accessibility while addressing resource constraints.

## III. AI APPLICATIONS IN KNOWLEDGE MANAGEMENT

Artificial Intelligence has shown significant potential in revolutionizing knowledge management practices across various sectors. Several key AI technologies and applications are particularly relevant to addressing the knowledge management needs of NRENs:

### A. Machine Learning for Knowledge Discovery and Pattern Recognition

Machine learning algorithms can analyze large volumes of data to uncover patterns, trends, and insights that may

not be immediately apparent to human observers. In the context of NRENs, this capability can be leveraged to identify emerging issues or trends in network performance [9], predict maintenance needs and optimize resource allocation [10], and discover knowledge gaps in existing documentation [11]. By automating these analytical tasks, NRENs can make more informed decisions and proactively address potential challenges.

### B. Natural Language Processing (NLP) and Information Retrieval

NLP techniques have greatly enhanced the ability to process and understand unstructured text data, which forms a significant portion of knowledge assets in NRENs. Advanced search and retrieval systems powered by NLP can improve the accessibility of information for NREN staff and stakeholders [12]. Semantic search enables users to find relevant information based on meaning rather than exact keyword matches [12], while automated tagging and categorization improve the organization of documents and resources for easier retrieval [2]. Additionally, question-answering systems provide direct answers to user queries by extracting relevant information from knowledge bases [13]. These technologies can significantly reduce the time spent searching for information, allowing NREN staff to focus on more value-added activities.

### C. Generative AI for Content Creation and Summarization

Recent advancements in generative AI, particularly large language models, have opened new possibilities for automating content creation and summarization [12]. For NRENs, this technology can be applied to generate initial drafts of technical documentation or reports [14], create summaries of lengthy documents or research papers [12], and produce multilingual versions of key resources to support international collaboration [15]. These applications can significantly reduce the time and effort required to create and maintain knowledge assets, allowing NRENs to keep their documentation up-to-date more efficiently.

### D. Collaborative Filtering and Recommendation Systems

AI-powered recommendation systems can enhance knowledge sharing and collaboration within NRENs by suggesting relevant resources to users based on their roles and past interactions [16]. They can also identify potential collaborators for research projects or problem-solving [17] and recommend training materials or best practices based on individual needs [18]. These systems can help overcome information silos and promote more effective knowledge utilization across the organization.

### E. Intelligent Process Automation

By combining AI with robotic process automation (RPA), NRENs can streamline various knowledge-related processes. Automated updating of documentation based on system changes [19], intelligent routing of support requests to the

most appropriate team or resource [20], and automated monitoring and reporting of knowledge base usage and effectiveness [21] are some key applications. These automations can reduce manual workload and improve the overall efficiency of knowledge management processes.

#### **IV. POTENTIAL IMPACT OF AI-POWERED KM SYSTEMS ON NREN EFFICIENCY**

The implementation of AI-powered knowledge management systems has the potential to significantly enhance operational efficiency and effectiveness in NRENs. Based on the applications discussed above, several key areas of impact can be identified.

##### ***A. Improved Knowledge Accessibility and Retrieval***

AI-driven search and retrieval systems can dramatically reduce the time and effort required to find relevant information [14]. This improvement can lead to faster problem resolution, as technical staff can quickly access relevant troubleshooting guides or past solutions. For managers, it enhances decision-making by providing easy access to comprehensive information that informs strategic choices. Furthermore, AI-powered systems can improve self-service for member institutions, allowing researchers and administrators to find answers to common questions without direct support, leading to greater autonomy and efficiency.

##### ***B. Enhanced Knowledge Creation and Maintenance***

Generative AI and intelligent automation can streamline the process of creating and updating knowledge assets [19] [14]. This capability results in more comprehensive and up-to-date documentation, reducing the risk of outdated or incomplete information. With AI, organizations can respond faster to technological changes, enabling quicker updates to technical guidelines and best practices. Additionally, AI frees up staff to focus on high-value content while automating routine updates, enhancing the overall capacity for knowledge creation.

##### ***C. Proactive Knowledge Management***

Machine learning and predictive analytics can enable NRENs to take a more proactive approach to knowledge management [9] [10]. This proactive approach brings several benefits, such as early identification of emerging issues, which allows for preemptive problem-solving and risk mitigation. Additionally, AI can optimize resource allocation by directing efforts towards areas with the highest knowledge needs or gaps. Through continuous improvement of knowledge assets, AI automatically identifies areas for enhancement based on usage patterns and feedback, ensuring that knowledge systems remain relevant and valuable over time.

##### ***D. Enhanced Collaboration and Knowledge Sharing***

AI-powered collaborative tools and recommendation systems foster better knowledge sharing and utilization across NRENs [17] [16]. These tools can increase cross-functional collaboration, breaking down silos between different teams or regions. More effective onboarding and training can be

achieved by providing personalized learning paths for new staff or member institutions. Additionally, AI can improve innovation and problem-solving by facilitating connections between experts and relevant knowledge resources, ensuring that the right expertise is accessible when needed.

##### ***E. Operational Efficiency and Cost Savings***

By automating various knowledge-related processes, AI can significantly contribute to operational efficiency and cost reduction [21] [20]. The potential benefits include reduced time spent on routine tasks, which frees up staff to focus on more strategic activities. AI can also lower support costs by improving self-service capabilities and enabling faster problem resolution. Moreover, AI contributes to more efficient use of resources by optimizing knowledge creation, maintenance, and dissemination processes, ultimately driving cost savings and better operational performance.

#### **V. POTENTIAL USES OF AI IN KNOWLEDGE MANAGEMENT**

##### ***A. Knowledge creation***

Artificial intelligence (AI) has emerged as a transformative force in the realm of knowledge creation, offering innovative tools and methodologies that enhance idea generation, content synthesis, and learning processes. In the context of idea generation, AI systems leverage vast datasets and advanced pattern recognition to identify trends and propose novel concepts, thereby streamlining creative processes across industries such as product development, strategic planning, and problem-solving. These systems not only generate innovative ideas but also provide data-driven insights that can inform decision-making and foster innovation. Additionally, AI plays a pivotal role in content synthesis by automating the aggregation and reinterpretation of information from diverse sources. This capability enables the creation of cohesive outputs, such as reports, articles, and research papers, which are particularly valuable in fields like scientific research, journalism, and knowledge management, where synthesizing large volumes of data is essential. Beyond generating ideas and synthesizing content, AI also serves as a powerful aid for learning and reflection. By offering contextual examples, detailed explanations, and diverse perspectives, AI-driven tools make complex concepts more accessible and encourage deeper understanding. These systems facilitate reflection and exploration, enabling users to develop nuanced insights and drive innovative thinking. Collectively, these advancements underscore AI's potential to revolutionize knowledge creation by enhancing creativity, efficiency, and intellectual exploration.

##### ***B. Knowledge storing & retrieving***

1) *Knowledge storing*: Generative AI has significantly advanced the processes of knowledge storage and retrieval, offering innovative solutions to organize, curate, and access information effectively. A critical contribution of AI lies in automated categorization and tagging, where systems efficiently

structure vast amounts of data by analyzing unstructured information and extracting key concepts. This ensures that knowledge repositories are well-organized, searchable, and capable of transforming disorganized data into structured, retrievable formats. Additionally, AI-driven knowledge curation plays a vital role in maintaining the quality and relevance of stored information. By identifying and archiving outdated or obsolete content, these systems ensure that knowledge repositories remain current and valuable, while also pinpointing areas that require updates or fresh insights [22]. This proactive approach prevents information overload and enhances the accessibility of high-quality, pertinent knowledge.

Generative AI also enables enhanced data integration, seamlessly combining information from diverse sources such as Customer Relationship Management (CRM) and Enterprise Resource Planning (ERP) systems. This integration creates comprehensive knowledge ecosystems that synthesize structured and unstructured datasets, improving visibility and empowering users to access relevant information quickly and efficiently. Furthermore, AI excels in intelligent knowledge extraction, analyzing large datasets to uncover patterns, trends, and insights. By extracting relevant details from documents, emails, audio recordings, and other sources, AI converts unstructured data into structured knowledge, ensuring that valuable information is captured and stored for future use. Lastly, generative AI supports the continuous improvement of knowledge storage systems by analyzing user interactions and feedback. These insights are used to refine existing knowledge assets and suggest updates, ensuring that repositories remain relevant, actionable, and aligned with evolving organizational needs [23]. Together, these capabilities highlight AI's transformative role in optimizing knowledge storage and retrieval, making it an indispensable tool for modern knowledge management systems.

2) *Knowledge retrieving*: Generative AI has significantly enhanced knowledge retrieval processes, introducing innovative tools and methodologies that make accessing information more intuitive, efficient, and personalized. One of the most transformative advancements is the use of conversational interfaces (chatbots) powered by natural language processing (NLP). These AI-driven tools enable users to interact with knowledge bases in a natural and intuitive manner, moving beyond traditional keyword-based search methods. By understanding user context and intent, chatbots deliver more accurate and relevant responses, particularly for complex queries or when users lack precise terminology [24]. This capability has made information retrieval more efficient and user-friendly, revolutionizing how users access knowledge.

In addition to conversational interfaces, advanced search services have been elevated through the integration of generative AI and NLP algorithms. These systems go beyond basic keyword matching to interpret user intent, analyze semantic relationships, and handle complex natural language queries. For instance, users can phrase questions conversationally and still receive precise results, significantly improving the relevance of retrieved information. This enhanced contextual understanding

streamlines decision-making and research processes, making knowledge retrieval more effective.

AI has also introduced personalized knowledge feeds, which tailor content delivery based on user-specific factors such as roles, preferences, and past behavior. By aligning knowledge feeds with individual needs, these systems ensure that users receive timely and relevant information, reducing information overload and boosting productivity. Personalized feeds make organizational knowledge more accessible and actionable, enhancing user engagement and efficiency.

Furthermore, generative AI has transformed expert search and recommendation systems. By analyzing employee contributions, skills, and project involvement, AI develops detailed expertise profiles and matches specific queries or project needs with the most qualified experts (Lee et al., 2024). This capability promotes knowledge sharing and collaboration within organizations, optimizing human capital and fostering effective knowledge transfer. Collectively, these advancements underscore AI's pivotal role in revolutionizing knowledge retrieval, making it more intuitive, personalized, and efficient.

### C. *Knowledge sharing*

Generative AI has fundamentally transformed collaboration, communication, and knowledge-sharing within organizations, making these processes more efficient, personalized, and accessible. One of its key contributions is enhanced collaboration and communication, where AI automates and simplifies knowledge-sharing by generating easily shareable documentation, summaries, and reports. These tools foster a common understanding among teams and streamline workflows. Additionally, AI-powered personalized recommendations connect individuals with relevant content or expertise tailored to their profiles and interests, promoting collaboration and resource optimization [25]. Interactive learning environments, such as simulated scenarios with instant feedback, further enhance engagement and enable real-time collaboration across diverse locations and time zones, breaking down geographical and temporal barriers.

Generative AI also excels in personalized knowledge delivery, tailoring knowledge-sharing experiences to individual needs. By analyzing user behavior, preferences, and knowledge gaps, these systems deliver customized content, including training materials that adapt to individual learning paces. Personalized feeds, based on roles, interests, and past interactions, ensure employees receive timely and relevant knowledge that directly supports their tasks and goals, enhancing productivity and engagement.

Moreover, AI significantly improves accessibility in knowledge sharing by addressing traditional barriers. Real-time translation capabilities enable seamless communication across different languages, supporting diverse and global workforces. Features like speech-to-text and text-to-speech make information accessible to individuals with disabilities, while AI's ability to simplify complex concepts into digestible formats broadens access to knowledge for wider audiences [26].

Finally, advanced search and retrieval capabilities powered by AI have redefined how users discover knowledge. By understanding natural language queries and interpreting complex questions, these systems provide precise and relevant answers, ensuring efficient access to information. Advanced search algorithms analyze extensive knowledge bases, while conversational interfaces like chatbots offer intuitive, dialogue-based methods for retrieving knowledge quickly and effectively. Collectively, these advancements highlight AI's transformative role in enhancing collaboration, personalization, accessibility, and efficiency in knowledge sharing.

#### ***D. Knowledge application***

Generative AI has become a cornerstone in enhancing decision-making, automating tasks, and ensuring the continuous and contextual application of knowledge within organizations. A key contribution is its ability to provide enhanced decision-making support. By synthesizing information from diverse sources, AI generates actionable insights, simulates various scenarios, and predicts potential outcomes. These data-driven recommendations, grounded in comprehensive analyses of organizational knowledge, empower leaders and teams to make more informed and strategic decisions, ultimately improving overall performance [27].

In addition to supporting decision-making, AI systems excel in automated task execution, applying knowledge to streamline routine and repetitive tasks. For instance, Generative AI can automate report generation, content creation, and data analysis, producing training materials, proposals, or articles based on existing data. This automation significantly reduces the time required for such tasks, allowing organizations to reallocate human resources toward higher-level strategic and creative activities.

Generative AI also fosters continuous learning and improvement by analyzing user interactions and feedback to refine knowledge assets. These systems proactively suggest updates, enhancements, and adjustments to existing content, ensuring that repositories remain relevant and aligned with evolving organizational needs. This dynamic process enables organizations to adapt quickly to changing information landscapes, maintaining a competitive edge in fast-paced environments.

Furthermore, AI excels in contextual knowledge application, delivering just-in-time information tailored to specific tasks or situations. By providing employees with the guidance they need precisely when they need it, AI ensures that knowledge is applied effectively and efficiently. Personalized recommendations based on an individual's role, expertise, and current project further enhance task relevance and efficiency. AI's ability to adapt knowledge strategies in response to real-time data and changing circumstances optimizes its application within dynamic environments, ensuring that organizations remain agile and responsive.

Collectively, these capabilities underscore AI's transformative role in enhancing decision-making, automating workflows, and enabling the continuous and contextual application of knowledge, driving organizational efficiency and innovation.

## **VI. CHALLENGES AND CONSIDERATIONS IN IMPLEMENTING AI-DRIVEN KM SOLUTIONS IN NRENS**

While the potential benefits of AI-powered knowledge management systems for NRENS are significant, several challenges and considerations must be addressed for successful implementation:

### ***A. Data Privacy and Security***

NRENS handle sensitive information related to network infrastructure and research data. Implementing AI systems requires careful consideration of data privacy and security implications [8], [28]. It is crucial to protect sensitive network information to ensure that AI systems do not inadvertently expose critical infrastructure details. Compliance with data protection regulations, such as GDPR in Europe, must also be maintained to avoid legal and ethical issues. Furthermore, the ethical use of AI in knowledge management should be prioritized by establishing guidelines that promote responsible AI implementation and safeguard user privacy.

### ***B. Integration with Existing Infrastructure***

NRENS often have complex, established IT infrastructures, making the integration of AI-powered knowledge management (KM) systems challenging [28], [29]. Compatibility with legacy systems is a major concern, as new AI solutions must be able to function alongside existing software and databases. Ensuring data quality and standardization is also critical, as inconsistencies in data formats across different systems can hinder effective AI adoption. Additionally, designing intuitive user interfaces that facilitate ease of use and encourage adoption of AI-powered tools is essential to maximizing their benefits within NREN environments.

### ***C. Resource Constraints***

As non-profit organizations, NRENS often face budgetary and expertise limitations when implementing advanced AI solutions [7]. The cost of implementation and maintenance must be carefully managed to balance financial investment with potential benefits. Additionally, skill gaps in AI and data science must be addressed, either by upskilling current employees or recruiting specialized personnel. Scalability is another concern, as AI solutions should be designed to grow with the organization's needs without leading to excessive cost increases.

### ***D. Change Management and User Adoption***

Introducing AI-powered KM systems often necessitates significant changes in work processes and organizational culture [30]. Resistance to change among staff may arise due to skepticism or fear of AI replacing human roles. To facilitate smooth adoption, organizations must provide adequate training and support to help users become comfortable with new systems. A balanced approach that integrates AI with human expertise ensures that AI augments rather than replaces knowledge workers, ultimately improving efficiency without eliminating valuable human insights.

### E. Ethical Considerations and Bias Mitigation

AI systems can unintentionally perpetuate or amplify biases present in their training data or algorithms [31]. NRENs must actively work to mitigate algorithmic bias to ensure that AI-generated recommendations or decisions do not unfairly disadvantage specific groups. Transparency and explainability in AI models are essential so that users can understand the rationale behind AI-generated outputs. Furthermore, accountability measures should be put in place to monitor AI performance and address potential ethical concerns that may arise in knowledge management applications.

### F. Multilingual and Multicultural Considerations

Many NRENs operate in diverse linguistic and cultural contexts, making it essential for AI-powered KM systems to accommodate multiple languages and cultural differences [15]. Supporting multilingual capabilities ensures effective knowledge sharing across language barriers, while culturally adaptive knowledge representation enhances engagement and usability. Promoting inclusivity is also crucial, as AI systems must be designed to serve all user groups equitably without marginalizing or excluding certain demographics.

Addressing these challenges requires a thoughtful, strategic approach to implementing AI-powered knowledge management systems in NRENs. By carefully considering these factors and developing appropriate mitigation strategies, NRENs can maximize the benefits of AI while minimizing potential risks and drawbacks.

## VII. CONCLUSION AND SYNTHESIS

This literature review has explored the potential of AI-powered knowledge management systems to enhance operational efficiency in National Research and Education Networks (NRENs). By examining current research on AI applications in knowledge management and considering the unique context of NRENs, several key conclusions can be drawn:

- 1) **AI offers significant potential for addressing NREN knowledge management challenges:** The diverse range of AI technologies, from natural language processing to machine learning and generative AI, can address many of the specific knowledge management needs of NRENs. These technologies can improve information retrieval, automate content creation and maintenance, enhance collaboration, and enable more proactive knowledge management approaches.
- 2) **Implementation of AI-powered KM systems can lead to substantial efficiency gains:** By streamlining knowledge-related processes, improving accessibility of information, and enabling more effective knowledge sharing, AI has the potential to significantly enhance operational efficiency in NRENs. This can lead to faster problem resolution, better decision-making, and more efficient use of resources.
- 3) **Challenges in implementation require careful consideration:** While the benefits are promising, NRENs

must navigate several challenges in implementing AI-powered KM systems. These include data privacy and security concerns, integration with existing infrastructure, resource constraints, change management issues, and ethical considerations. Addressing these challenges is crucial for the successful adoption and long-term sustainability of AI-driven knowledge management solutions.

- 4) **A tailored approach is necessary:** Given the unique characteristics and needs of NRENs, off-the-shelf AI solutions may not be sufficient. Developing AI-powered KM systems that are specifically designed for NREN environments, taking into account their diverse stakeholders, technical requirements, and operational contexts, is essential for maximizing benefits and ensuring adoption.
- 5) **Human expertise remains crucial:** While AI can significantly enhance knowledge management processes, human expertise and oversight remain critical. AI should be viewed as a tool to augment human capabilities rather than replace them, particularly in complex decision-making and strategic planning roles within NRENs.
- 6) **Continuous evaluation and adaptation are key:** As both AI technologies and NREN needs evolve, ongoing assessment and refinement of AI-powered KM systems will be necessary to ensure their continued effectiveness and relevance.

This review highlights the need for further research and practical implementations in several areas:

- Developing and testing AI-powered KM prototypes specifically designed for NREN environments
- Conducting empirical studies on the impact of AI-driven knowledge management on NREN operational efficiency and effectiveness
- Exploring best practices for integrating AI solutions with existing NREN infrastructure and processes
- Investigating ethical frameworks and governance models for AI use in NREN knowledge management
- Examining the long-term implications of AI adoption on NREN organizational culture and human resource development

By addressing these research gaps and building on the insights from existing literature, NRENs can develop innovative, effective approaches to knowledge management that leverage the power of AI while addressing their unique needs and challenges. This, in turn, can enhance their ability to support the broader academic and research communities they serve, ultimately contributing to advancements in education and scientific discovery.

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