Application of Semantic Technologies in the Digital Transformation of the National Academy of Sciences of Ukraine

Julia Rogushina[1,2*], Igor Sinitsyn[1]

[1] *Institute of Software Systems, National Academy of Sciences of Ukraine, 44 Glushkov Pr., Kyiv, 03680, Ukraine,*
[2] *Institute for Digitalisation of Education, National Academy of Educational Sciences of Ukraine, 9 M. Berlynskoho Str., Kyiv, 04060, Ukraine*

Abstract

The study underscores the importance of leveraging Ukraine's significant scientific potential amidst geopolitical challenges to align with international standards and stimulate inclusive and knowledge-intensive progress. We analyze the current directions of digital transformation and the specifics of its implementation for the National Academy of Sciences of Ukraine (NASU) according to the foundational principles of Open Science and the specific characteristics of the Academy's existing ecosystem. In this study we examine elements of semantic technologies that facilitate the integration of NASU informational resources with Open Science services and their incorporation into the Academy's business processes and propose the development of a repository based on semantic Wiki technologies to serve as an advanced platform for representation information about NASU core research objects. This technological solution aligns with FAIR principles aims to address the gaps in cross-search functionalities, ensure scalability, support metadata management and provide tools for collaborative content creation. Such advancements are expected to accelerate the digital transformation of NASU, enhance its role in the global scientific community and strengthen its contribution to innovation-driven economic development.

Keywords
Digital transformation, informational ecosystem, semantic Wiki.

1. Introduction

Currently, the necessity of digital transformation (DT) aligns with the requirements of Ukraine across numerous sectors. The relevance of this process is substantiated by the laws and regulations adopted in recent years, focusing on strategies for digital development, transformation, and the digitization of the economy, science, culture and education. International experiences illustrate the potential outcomes and directions of its implementation. However, the challenge lies in the fact that DT is a complex, multi-component concept, and its implementation is largely shaped by the following factors: the specific characteristics of the domain where it is applied; the available resources for DT implementation; and both current and strategic priorities of this domain. Hence, it is advisable to define more precisely and formally the fundamental concepts employed in DT for such specific field as an academic science and the relationships between these concepts.

This work analyzes the main requirements to digital transformation within the National Academy of Sciences of Ukraine (NASU) (www.nas.gov.ua). Not only its scale determines its

---

[1] *Workshop "Software engineering and semantic technologies" SEST, co-located with 15th International Scientific and Practical Programming Conference UkrPROG'2025*, May 13-14, 2025, Kyiv, Ukraine
* Corresponding author.
ladamandraka2010@gmail.com (J.Rogushina); ips2014@ukr.net (I.Sinitsyn)
0000-0001-7958-2557 (J.Rogushina); 0000-0002-4120-0784 (I.Sinitsyn)

uniqueness - the NASU encompasses a substantial number of institutions and subdivisions, but also by its objectives. The primary mission of the NASU is to generate new knowledge and synthesize existing knowledge across various fields. Consequently, the DT process requires the most efficient integration of information systems and technologies aimed at knowledge acquisition and application, as well as the support of business processes in academic science. This approach facilitates the transition from the general DT concept to a concrete implementation program oriented on the NASU goals.

The NASU DT has to take into account the following components:

- Open science: promoting open access to publications, data sets, and tools of research process;
- Data analysis: analysis of big data, use of artificial intelligence and machine learning for process complex data sets and generation new knowledge and hypotheses;
- Collaboration platforms for researchers: use of cloud-based tools and platforms to ensure global collaboration within secure information environments and to solve interdisciplinary scientific challenges;
- Modeling tools for complex systems and experiments: supporting the exploration and simulation of intricate scientific problems.

2. Digital transformation, information technologies and informatization

DT is the subject of many scientific studies and integrates a significant number of concepts and scientific directions (Figure 1). Research in DT area is divided into three main clusters: digital business transformation; technology as a driving force of digital transformation; and institutional and societal implications of digital transformation.

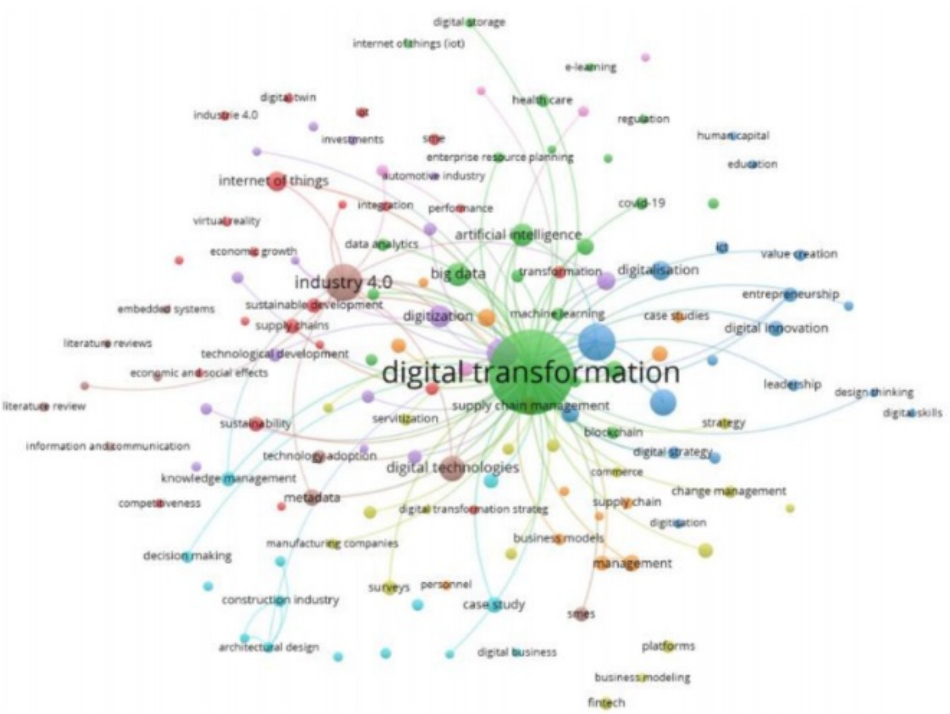

Figure 1: Bibliometric card of digital transformation concept

Digital Transformation (DT) is a transformation of a specific area of activity with revisions of its fundamental strategies through the implementation of *information technologies* (IT) aimed at improving efficiency of results in this area. Its objectives include enhancing interaction and collaboration within the domain through digital tools and platforms, fostering innovation in business models, optimizing and automating workflows via digital tools, supporting data-driven decision-making and achieving technological integration.

According to UNESCO's definition, IT encompasses interconnected scientific, technological, and engineering disciplines that study methods for effectively organizing activities and interactions between individuals aimed at information processing and storing, as well as their practical applications. The IT development influences the societal progress and transformation to the informational society, where information becomes a key resource and product of activity. IT can be considered as a system of methods and instruments for collecting, accumulating, storing, searching and processing of information. Modern ITs are bases on computer engineering and computer networks.

DT is frequently misunderstood as merely converting analog information into digital formats and transitioning to paperless technologies. However, DT is a broader concept that also analyzes how IT affects products, processes, and organizational activities, determines the benefits it provides, considers both positive and negative impacts, and enables their integration and scalability.

It is crucial to recognize that global processes of DT in societal development, driven by modern IT directions (such as artificial intelligence, cloud computing, IoT, and augmented reality), bring serious challenges, threats and risks that need to be anticipated and to solve according to requirements of cyber security and personal data protection. IT becomes a critical component in the creation of the information society where most individuals are engaged in creating, storing, processing, and utilizing information.

At the information society *the generation of new knowledge* and reuse of existing knowledge become foundational factors for its functioning and innovative development. *Scientific activity* serves as the main source of new knowledge within society. Therefore, the digital transformation of scientific institutions and research as a whole becomes one of the most essential conditions for societal development. To achieve this, we have to formulate a concept of digital transformation for NASU in general and define priorities for individual DT initiatives, analyzing their impact on the development of Ukrainian science and the complexity of their implementation.

The transition to an information society is often linked to the notion of informatization that creates conditions for meeting the information needs of society and its citizens. Informatization is based on computational and communication technology and the creation of information systems and networks founded on it.

Informatization differs significantly from DT and pertains to the process of deploying IT to improve efficiency, productivity, and data management within an organization or society. Unlike DT, informatization focuses primarily on the technical implementation of IT systems rather than broader strategic and cultural changes associated with digital transformation. Therefore, we can consider informatization as a key component of DT.

Core elements of informatization are:

- development of IT infrastructure that includes building and deploying hardware, software, and networks to support information processing;
- digitization of data by converting analogue information into digital formats for easier storage, access and processing;
- automation of processes with using IT systems for routine tasks and enhance work efficiency;
- information management for systematic organizing, storing, and retrieval of data;
- standardization of IT systems and protocols within an organization or industry.

Table 1
Key Differences Between Digital Transformation and Informatization

	Digital Transformation	Informatization
Scope	Broad, encompassing strategy, culture, and technology	Narrow, focused on IT implementation and data management.
Goal	Fostering innovation, new business models, and improving interaction.	Enhancing efficiency and data processing.
Focus	External (customer-oriented) and internal (operational).	Primarily internal (operational focus).
Technologies	Advanced IT (AI, Internet of Things, blockchain, cloud computing).	Basic IT systems (databases, networks, software).
Outcome	Fundamental shifts in business processes affecting competitiveness.	Improves existing processes and systems.
Impacts	Significant cultural and organizational changes.	Minimal cultural changes (basic digital literacy); some technical adjustments.

Key issues in DT are:

- identifying and addressing the real informational needs of users and establishing information exchange between them.
- improving operational processes based on digital tools for processing and analyzing information to support decision-making.

Thus, informatization is a narrower technical process compared to the holistic strategy of DT. However, informatization forms the foundation for DT, defining approaches to leveraging IT for stimulating innovation and achieving long-term competitive advantages.

Factors that define DT efficiency are: methodology; tools; platforms; and roadmaps. Successful DT requires not only the application of existing IT and the development of new technologies that meet requirements but also the establishment of methodologies for their use, selection of relevant tools and technological platforms. Important part of DT is a construction of a strategic roadmap that ensures its successful integration with current needs of domain.

3. Strategic directions and prospects for the development of science in Ukraine

The strategy for digital development of innovation activity in Ukraine for the period up to 2030 (Resolution No. 1351-p, December 31, 2024, zakon.rada.gov.ua/laws/show/1351-2024-p#n14) envisages the advancement of knowledge-intensive innovations. It includes measures to develop the scientific foundation for innovations, with strategic goals such as enhancing capacities for the creation of knowledge-intensive innovations, establishing conditions for the development of internal research infrastructure and developing products in the cyber security field. This document outlines tasks and measures to achieve these goals, including the development of a unified platform for the collection, analysis, and exchange of data in the field of science and innovation.

The majority of researchers are concentrated in public sector organizations, a significant portion of which is subordinate to the National Academy of Sciences of Ukraine (NASU). This underscores the relevance of studying the directions of digital transformation within NASU and analyzing its implementation.

The analysis of the scientific community's assessment of the current state of Ukraine's scientific, technical and innovation policies and prospects defines their improvement, goals and new approaches for implementation [1] where theoretical and practical foundations of the DT of scientific and educational activities are considered one of the thematic blocks, “Digital Technologies, Artificial Intelligence, and Cyber security.”

Results of this research can demonstrate the relative interest of researchers in subdirections of DT in the NASU. However, its actuality evaluation is relatively low. The study of this block involved 37 experts, including four academicians and corresponding members of NASU, 23 doctors, and 10 candidates of sciences. This research identifies societal and scientific needs and expectations regarding the relevance of specific elements of DT within NASU, as well as the potential and resources for their implementation. However, it is important to note that the study is based on the subjective opinions of researchers specialized in entirely different fields, rather than on an objective analysis of real digitalization outcomes and their technological and organizational prerequisites.

It is worth noting that the focus is predominantly on popular IT applications, such as securing the information environment and artificial intelligence applications based on neural networks, without delving into their theoretical basis.

The study does not address topics such as semantic technologies, decision-support tools, advisory systems, parallel computing, pattern recognition, service-oriented computing, or agent-based programming paradigms (probably, because the narrow specialization and expertise required to understand such issues, that are generally accessible only to IT specialists and software developers rather than researchers focused on utilizing ready-made technological solutions). Consequently, another element of this thematic block “Rapid conversion of scientific research into breakthrough applied developments based on extensive cooperation” arouses interest, as its relevance is rated highly at 82%.

The majority of experts associate IT development prospects with methods for transforming and applying theoretical knowledge into practical solutions and integrating knowledge from different domains. Accordingly, the DT program for NASU should incorporate the development of communication tools between researchers and businesses, as well as various services for matching scientific projects being developed within the academy with the needs of potential clients in practical domains. *Semantic technologies* could be utilized for modeling and deriving knowledge from existing information, searching, and matching complex information objects considering the specific conditions of various subject areas, and processing fuzzy information, not limited solely to neural networks and large language models.

Such approach helps in defining priorities for scientific research and identifying technological and organizational means to enhance NASU's activities in response to challenges of scientific development in Ukraine under the conditions of full-scale war that significantly limits the state's resources for the DT purposes but actualizes its goals. Therefore, we try to analyze main groups of NASU subjects that can be interested in various ways of DT.

4. The NASU informational ecosystem

The ecosystem concept is a powerful tool for formalizing fundamental connections (informational and material) between subjects of a complex system, the resources they jointly utilize, and the exchanges by results of their activities [2]. This approach allows for more accurate modeling of systems where subjects jointly use specific resources, compete for access to them, and where the results of one-subject activities can serve as resources for others [3].

We have to recognize that such ecosystem exists objectively, but its qualitative modeling enables forecasting directions of its development and influences this process. For instance, DT can be modeled as a tool that accelerates information exchange within the ecosystem and simplifies access to the results of its subject’s activities. Ecosystem model analysis allows the identification of the connections that have the greatest impact on the overall functioning of the system or cause specific problems, thereby necessitating improvement [4].

Moreover, this model illustrates how resource redistribution can influence the state and results of the ecosystem's elements. For instance, expanding access to certain informational resources within the ecosystem requires relatively minor additional material resources but can help avoid costly duplication of creating such information.

This aspect is particularly relevant to ecosystems where a significant portion of activities result in informational products, or where it is deemed appropriate to develop the system in this direction. Therefore, in developing the DT concept for NASU, that inherently generates complex, knowledge-intensive informational objects (scientific research results, innovative technologies, analytical materials, etc.), it is advisable to analyze its ecosystem to model various development scenarios. Representation of this model needs in adequate tools and standards of knowledge representation and management (such as ontological analysis [5] and the Semantic Web technologies [6]).

The NASU ecosystem models knowledge about the academy's activities, its components, and the transformation of available resources into outcomes.

The subjects of the NASU ecosystem include the following groups of users distinguished by their informational needs, objectives, and capacities to process information:

- researchers engaged in theoretical and applied research in various scientific fields within NASU;
- administrators and managers of NASU scientific units who direct the work of other researchers;
- staff of NASU administrative units responsible for supporting scientific research processes;
- representatives of Ukrainian and international businesses, as well as governmental institutions, utilizing NASU research results for innovative changes in their activities;
- members of educational organizations applying new scientific results in the learning process.

In addition, the subjects of this ecosystem are organizations, institutions, government bodies and their subdivisions, that define meaningful relationships among users. The ecosystem model reflects not only hierarchical relationships (such as "institution-subdivision" or "subdivision-employee") and horizontal relationships (such as "employees of the same department" or "subdivisions within one institution") but also more intricate semantic relationships characteristic of scientific activities (e.g., "co-authors," "collaboration between institutions," or "participation in a grant") or complex organizational structures (e.g., "provides data to a subdivision," "monitors performance results").

Analyzing these relationships helps to identify frequently used sequences that demand greater effort for optimization. This analysis can became more efficient by the use of external knowledge regarding the characteristics of these relationships, which can be obtained from corresponding organizational ontologies or domain-specific ontologies. This aspect plays a particularly significant role for NASU, where similar terms for resources and results in different research fields can define entirely different concepts.

Ontological model of NASU ecosystem (Fig.2) formalizes properties of its main subjects (biotic components) and objects (abiotic components), defines semantics of their possible relations. It distinguishes different relations of the individuals of the same classes. For example, it can define that Service S1 "is developed by" Organization A or Service S2 "is used by" Organization B.

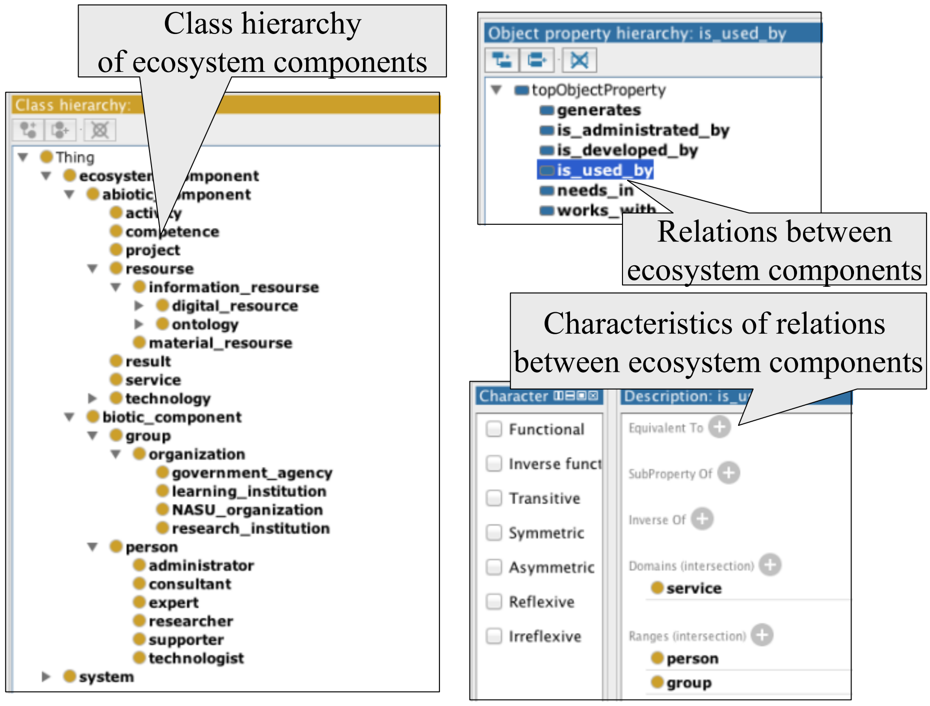

Figure 2: Elements of NASU ecosystem ontology

Visual representation of this model based on Ontograf plugin of Protégé editor (Fig.3) can be used for creation and optimization of intelligent applications for NASU DT.

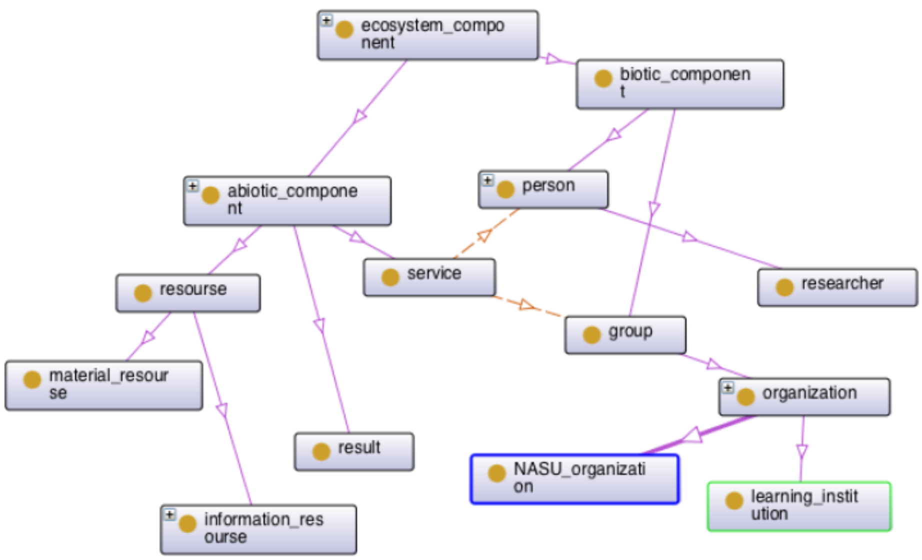

Figure 3: Visual representation of NASU ecosystem ontology (fragment)

5. Main directions of NASU digital transformation

General DT trends across various fields and sectors are characterized by the shift from informatization of key directions to the development of an integrated and secure informational environment, and from merely accumulating and storing digital representations of informational resources to analyzing and practically applying them to address pressing issues. These trends manifest in the challenges addressed by the digital transformation of NASU, particularly the creation of a secure and confidential informational environment that provides the following main functions:

- ensures the integrity and accessibility of information, protects the personal data of NASU employees;
- provides access to scientific research outcomes (publications, scientific reports, datasets, and experimental samples), re presented in open formats in accordance with the concept of Open science;
- enhances transparency in administrative procedures, services, and decision-making processes within NASU;
- provides platform for collaboration within the scientific community at both national and international levels and enables scaling up of best practices;
- promotes the digital culture of NASU employees and ensures the safe utilization of various scientific services and platforms.

A distinctive feature of DT for NASU is its comprehensiveness and focus on integrated solutions to create a digital ecosystem for science-related decisions and to provide the necessary infrastructure for the Presidium of NASU and its scientific institutions. The outcome of NASU's digital transformation is intended to support researchers at all stages of their scientific work and ensure access to a complete suite of services related to reporting, communication, academic integrity, and fulfilling informational and analytical needs. Special attention is given to the high knowledge-intensity of both the researchers' outputs and the informational resources they rely upon.

An analysis of the existing elements of NASU informational ecosystem and prospective directions for its digital transformation shows the following challenges:

- electronic document management system of NASU is predominantly designed to meet the needs of NASU administration and Presidium. However, it does not oriented to the informational needs of individual researchers or external users who wish to utilize scientific research outcomes;
- Presidium of NASU (www.nas.gov.ua) and other Academia`s institutions are represented online, but their websites are not integrated, they do not support cross-site search functionality, and do not allow connections between scientific projects and individual researchers. Typically, these websites serve as "business card" sites (e.g., the website of the Institute of Software Systems of NASU (iss.nas.gov.ua) contains contact information for the institution, its director and administration, lists of primary research directions and announcements of scientific events);
- the processing of scientometric databases oriented on the quantitatively assessing the activities of individual researchers and research teams of NASU ecosystem is weakly correlated with NASU structures. Available integration tools (e.g., Bibliometrics of Ukrainian Science (nbuviap.gov.ua/bpnu/index.php?page_sites=poisk) that supports searches in Google Scholar and Scopus by Ukrainian institutions, cities, and scientific fields frequently contain outdated information;
- content management for institutional websites and the document management system is handled exclusively by authorized personnel, meaning researchers themselves cannot update information about their work or developments.

Highlighted directions of NASU digital transformation include:

- support of the scientific research processes to generate new knowledge, technologies, and innovations;
- training qualified personnel for the scientific industry;

- expanding cooperation with other scientific institutions and organizations, both nationally and internationally;
- modernizing and integrating of NASU informational infrastructure;
- support of cyber security and information protection issues.

Specific requirements of NASU for digital transformation DT process include:

- the maximized use of existing informational assets of NASU (both digital and non-digital), such as databases, libraries of scientific materials, etc. by converting them into a unified digital space;
- providing convenient and secure tools for collecting, storing and retrieval of information on research activities (scientific reports, work plans, publication lists, etc.), along with adaptive feedback mechanisms for content authors (NASU researchers);
- supporting existing practices for conducting scientific research and organizing scientific events (e.g., conferences, workshops, meetings) with gradual implementation of digital services based on an analysis of best practices, considering the capabilities of the existing technical infrastructure;
- broad integration of informal and non-formal training methods to enhance digital competence among NASU employees, organizing information campaigns about new tools and opportunities, developing personalized learning pathways for remote training tailored to different user groups, in collaboration with educational institutions.
- facilitating communication between Ukrainian scientists and the global scientific community by providing free and secure access to international scientometric databases, scientific libraries, repositories, peer review systems, translation and plagiarism-check services, semantic search systems, and knowledge bases.

The primary objective of NASU's digital transformation is to make the scientific activities of Ukrainian researchers more productive while supporting the concept of open science at all stages of research.

6. Use of Open Science tools for NASU digital transformation

The concept of Open Science [7] is intended to serve as a tool for enhancing the quality, efficiency, and timeliness of scientific activities by ensuring free and open access to both scientific publications and experimental data, extending the principles of openness to the entire lifecycle of creating scientific outcomes.

The concept of Open Science is much broader then access to scientific publications because it extends to the entire lifecycle of research process and the involvement of external users, provides transparency in research methodologies and the use of open data formats. Open Science supports a broader context for scientific outcomes, including the publication of intermediate and final experimental results, pre-publication dissemination of research for preliminary discussion, transparency in methodology, open peer review, engagement of a wider audience, enhancement of trust in findings, and their reproducibility. It also encourages the examination of data collection methods, adoption of best international scientific practices, evolution of research culture, and use of collaborative platforms for disseminating scientific outcomes. Additionally, Open Science aims to popularize and simplify access to scientific findings for external users, striking a balance between openness and intellectual property protection. Key elements include the open sharing of scientific datasets via repositories (there are currently 4,000 such repositories), improvement in the evaluation of scientific and educational data and publications, and fostering competencies in Open Science.

Taxonomy of Open Science components [8] divides them in following groups (Fig.4):

- open knowledge (publications, data, software, educational resources);

- open scientific infrastructure;
- open interaction with other sources of knowledge;
- open collaboration.

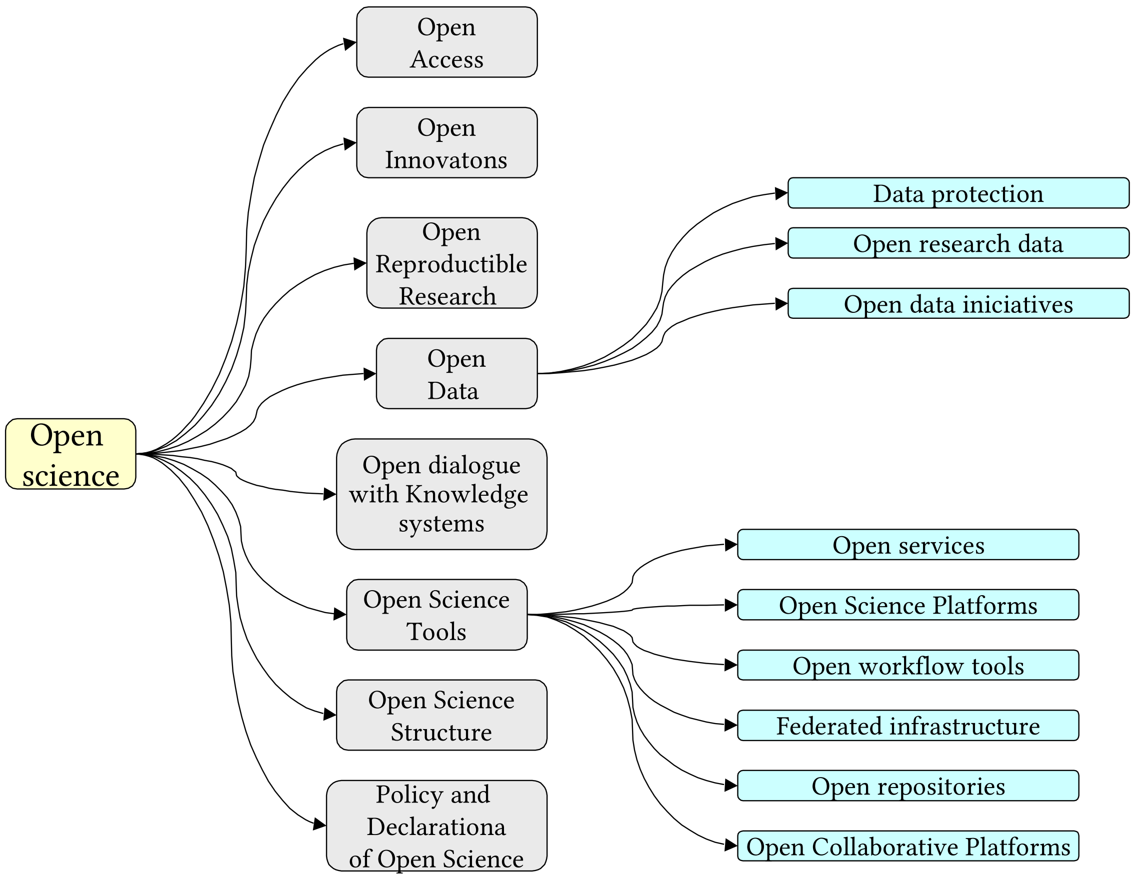

Figure 4: Taxonomy of Open Science (fragment).

Open Science principles form the base for effective collaboration among scientists, reproducibility of findings, and the promotion of scientific results. Research data management tools [9] are designed to support all stages of the data lifecycle, including creation, preservation, access and use.

Ensuring FAIR principles [10] is a crucial tool for optimizing access to scientific data [11]. In 2022, the Ukrainian Cabinet of Ministers approved a National plan for Open Science, adopting FAIR as a foundational framework for defining principles for the dissemination of scientific data and open access to scientific results. Consequently, DT of scientific research has to incorporate these principles and prioritize tools and technologies that align with FAIR requirements, such as those employing open-source software and open data formats.

A variety of tools are developed to support and enhance scientific efficiency. Some of them are applicable across all research fields (e.g., publication support through bibliographic managers and open data repositories, or project management tools for documenting various research lifecycle stages), while others are field-specific (e.g., tools for data visualization, qualitative and quantitative analysis). Many tools are provided free of charge within international projects. Furthermore, various national and departmental projects create services and repositories to support datasets and publications, supplementing existing Open Science platforms according to specific country or institutional requirements (e.g., adding national formats to bibliographic managers) or offering additional services (e.g., categorizing information from bibliometric databases for NASU institutions).

The European Open Science Cloud (EOSC) is a significant source of such tools [12] that can be used by NASU researchers. Example of the scientific service is Zenodo [13], a platform for disseminating and attributing research results. Its key feature is the ability to deposit scientific articles, books and conference abstracts but also various types of information objects (e.g., presentation slides, events, images, video/audio files, datasets, patents, reviews, taxonomies, standards) by generating of the unique DOI for each object. Registered users via ORCID can upload files, specify their type, and add them to bibliographic records. Documents and presentations are recommended to be stored in PDF format. Users can explicitly indicate their role in publishing the data—whether as individual researchers, research groups, right holders, or contact persons. Data descriptions can be added in multiple languages. The system assists in selecting a license (most commonly CC BY 4.0), defining the terms for referencing and using the published materials. This enables the dissemination of intermediate research outcomes, saves intellectual property and ensures data integrity.

Other group of scientific services is bibliographic managers that provide instruments for automated processing and transforming of references in scientific publications. For example, Zotero [14] allows the import of references in different formats (e.g., BibTeX) and supports group collaboration on reference catalogs, sharing databases, various citation styles, and automatic bibliographic formatting. Another popular bibliographic manager, Mendeley, also offers a free version.

Data management plans are required in many international and national research projects. For example, Argos [15] supports management of scientific data by describing data volume, accessibility, formats, interoperability, openness and storage locations, essentially providing a "roadmap" for data work, including project oversight and verification.

Thus, the DT focus of NASU can be oriented not only on developing original researcher tools but on detailed analysis, dissemination of knowledge (both potential capabilities and application features) and ensuring secure access to existing systems, portals and services.

7. Semantic Wiki technologies as an element of NASU ecosystem improvement

The analysis of existing issues highlights the need to supplement current informatization tools with semantic services that can integrate existing digital resources and document systems of NASU with FAIR-based services of Open Science, replenishing them by specialized recommending system that helps researchers in retrieval of the most pertinent instruments for their personalized scientific activities.

Consequently, we define a need to enhance the existing ecosystem with an integrated repository that allows semantic search requests based on formal criteria (specialization, institution, title, position, etc.) and informal descriptions (area of expertise, research topics, citation indices, etc.) among the complex information objects [16]. This tool would facilitate a technology for conversational knowledge management and group collaboration and that optimizes the search for reviewers, research supervisors, opponents, etc. Additionally, it would enable external users to identify potential partners and experts within NASU.

Such repository can be developed on base of the wiki technologies [17], for example, MediaWiki [18] and its semantic extension Semantic MediaWiki [19]. This open-source software fully complies with all FAIR requirements [20]. Wiki technology is scalable, oriented on common generation of content by multiple users and has a lot of solutions for integration with external knowledge bases. Repositories built on this platform for individual institutions of NASU on base of the common knowledge representation structure can be easily integrated. Semantic MediaWiki functionality provides a broad range of analytical capabilities and semantic search tools.

Web-oriented repositories become powerful informational resources aimed at providing users with relevant and up-to-date information. These systems act as tools for shaping the conceptual and terminological framework of various subject areas within the Open Science paradigm. A similar solution is implemented by the Institute of Digitalization of Education of the National Academy of Pedagogical Sciences (eduglos.iitta.gov.ua), which presents information about educational institutions in Ukraine, their employees, and research areas. The Ukrainian Electronic Encyclopedia of Education (UEEO) serves as an information resource that offers users comprehensive articles with multimedia elements describing institutions, individuals, and fundamental concepts related to education development [21].

Content can be added and updated by those who directly interested in disseminating their scientific results – for instance, project managers, conference program committee members and journal editorial board members. This approach reduces redundant data entry, streamline researcher communication and facilitate cross-resource search queries within the NASU ecosystem.

The advantages of a semantic wiki repository are as follows [22]:

- familiarity with well-known wiki technologies (for example, Wikipedia, Wikidata) simplifies user training in collaborative population of repository content (all researcher of NASU can input information about their scientific activities without assistance and actually);
- the use of open-source software and open data formats enhances integration with other scientific platforms (both used by NASU and by international scientific communities) and facilitates resource protection;
- unified wiki content representation based on specialized templates ensures standardized information submission and ease of design updates;
- Wiki technology supports collaborative content creation, thus ensuring greater relevance of information about researchers and teams interested in collaboration and dissemination of results;
- repository can serve as a unified researcher workspace, representing access ways to external data and services with their characteristics and instructions.
- semantic markup of content explicitly establishes connections between all elements of NASU ecosystem (persons, subdivisions, projects, publications, environment, etc.) at various levels of detail, aligning with FAIR metadata and open data search requirements;
- content protection from intentional and unintentional damage via technology (wiki ensures rollback to previous versions).
- Wiki technology supports scalability and integration across resources (e.g., Wikipedia effectively manages hundreds of thousands of pages while ensuring rapid navigation and search) and integration with external resources and repositories;
- Wiki has a lot of plugins that support semantic search based on complex conditions, the creation of integrator pages with query results, transforming the repository into an analytical web portal complemented by external tools for deeper analysis and visualization of content;
- Semantic extension Wiki provides export options for search results into the knowledge representation formats of the Semantic Web (RDF, OWL) that can be utilized by external semantic applications.

Moreover, wiki resources are not demanding on user hardware and can operate effectively on various computer equipment that is critically important for current NASU' technical state.

This repository can contain is wiki pages of the following categories corresponded to NASU ecosystem elements:

- NASU institutions and their subdivisions;
- scientists and other NASU employees;

- scientific projects and grants;
- academic publications (monographs, textbooks, reference materials);
- scientific journals and periodic publications;
- conferences and seminars;
- scientific concepts across various domains;
- instructions for scientific services, scientometric data bases, external repositories and libraries;

Special group of pages integrate data from other pages based on common user information needs.

8. Conclusions

The research and analysis conducted on the digital transformation in Ukraine, along with reviews of the current state and goals of its development, emphasize the potential for implementing semantic technologies. These technologies can enhance the integration, updating and utilization of NASU informational resources, thereby boosting its scientific capabilities. The adoption of Open Science principles and modern tools such as semantic wiki-repository can significantly improve efficiency, transparency and accessibility in NASU digital ecosystem. This approach is aimed to provide the base for broader national and international collaboration and innovation in scientific sphere. Leveraging Ukraine's strong scientific potential through focused digital transformation efforts can support the research ecosystem of our country and further align its practices with global standards in science and technology.

The study underscores the importance of adopting semantic technologies to transform NASU digital ecosystem into a scalable, user-driven network that supports Open Science practices. By incorporating semantic Wiki resources, the Academy could bridge existing gaps, modernize research processes and bolster its global scientific standing. These advancements promise to enhance the accessibility and impact of Ukrainian science in alignment with international standards for innovation and knowledge sharing.

Declaration on Generative AI

During the preparation of this work, the authors used AI program Copilot for correction of text grammar. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

References

[1] Ukrainian Scientific and Technical Foresight. Strategic Priority Directions and Prospects for the Development of Science and Technology. (2024). foresight.in.ua/UkrSciTechForesight2024.pdf.

[2] W. Geary et al., A guide to ecosystem models and their environmental applications. Nature Ecology & Evolution, 4 (2020), 1459-1471. doi:10.1038/s41559-020-01298-8.

[3] J. Howison, E. Deelman, M. J. McLennan, R. Ferreira da Silva, J. D. Herbsleb, Understanding the scientific software ecosystem and its impact: Current and future measures. Research Evaluation, 24(4) (2015), 454-470.

[4] S. Jansen, A. Finkelstein, S. Brinkkemper, A sense of community: A research agenda for software ecosystems, in: Proceedings of 31st International Conference on Software Engineering, May 2009, pp. 187-190. IEEE.

[5] N. Guarino, Formal ontology, conceptual analysis and knowledge representation. In: International journal of human-computer studies, 43(5-6), 1995. 625-640.

[6] J. Davies, D. Fensel, F. van Harmelen, Towards the Semantic Web: Ontology-driven knowledge management. John Wiley Sons Ltd. England. 2002. 288 p.

[7] UNESCO (2022). Understanding open science — Factsheet — SC-PBS-STIP/2022/OST/1. Paris, France: UNESCO. doi:10.54677/UTCD9302.
[8] N., Pontika, P., Knoth, M., Cancellieri, & S., Pearce, Fostering open science to research using a taxonomy and an eLearning portal. In: Proceedings of the 15th international conference on knowledge technologies and data-driven business, 2015: 1-8. https://oro.open.ac.uk/44719/2/kmi_foster_iknow.pdf.
[9] Methodological Recommendations for Research Data Management for Higher Education Institutions and Research Organizations Regarding Mechanisms for Data Preservation and Reuse. https://mon.gov.ua/static-objects/mon/sites/1/nauka/2024/12/31/metod-rekomendatsiyi-shchodo-upravlinnya-naukovymy-danymy-31-12-2024.pdf.
[10] M. Boeckhout, G. Zielhuis, A.I. Bredenoord, The FAIR guiding principles for data stewardship: fair enough? In: European journal of human genetics, 26(7), 2018, pp.931-936. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6018669/.
[11] The FAIR Guiding Principles for scientific data management and stewardship. URL: https://www.nature.com/articles/sdata201618.
[12] P., Budroni, J., Claude-Burgelman, & M., Schouppe, Architectures of knowledge: the European open science cloud. ABI Technik, 39(2), (2019): 130-141.
[13] I. Peters, P., Kraker, E., Lex, C., Gumpenberger, & I. J. Gorraiz, Zenodo in the spotlight of traditional and new metrics. In: Frontiers in research metrics and analytics, 2, (2017): 1-13.
[14] K. K., Mueen Ahmed, & B. E. A. Dhubaib, Zotero: A bibliographic assistant to researcher. In: Journal of Pharmacology and Pharmacotherapeutics, 2(4), (2011): 304-305.
[15] E., Papadopoulou, A., Bardi, G., Kakaletris, D., Tziotzios, P., Manghi, & N., Manola, Data management plans as linked open data: exploiting ARGOS FAIR and machine actionable outputs in the OpenAIRE research graph. In: Journal of Biomedical Semantics, 14(1), (2023): 17-32.
[16] J., Rogushina, & A., Gladun, Repository of Complex Information Objects as a Source for Development of Semantic Applications, in: XXIII International Scientific and Practical Conference Information Technologies and Security ITS 2023, CEUR Vol-3887, (2024): 119-133. https://ceur-ws.org/Vol-3887/paper11.pdf.
[17] C. Wagner Wiki: A technology for conversational knowledge management and group collaboration. The Communications of the Association for Information Systems, 2004, 13(1), pp.264-289.
[18] P. Haase, D. Herzig, M. Musen, M., T. Tran, Semantic wiki search In: The Semantic Web: Research and Applications: 6th European Semantic Web Conference, ESWC 2009 Heraklion, Crete, Greece, Proceedings 6, Springer Berlin Heidelberg, 2009: 445-460.
[19] Y. Koren, Working with MediaWiki, San Bernardino, CA, USA: WikiWorks Press. 2012, pp. 157–159.
[20] J., Rogushina, Use of ontologies and semantic mediawiki for representation and retrieval of scientific data in the FAIR paradigm. In: Proc.of International scientific conference "Information technologies and management in higher education and sciences", CEUR Workshop Proceedings. Vol. 2866. (2023): 61–73.
[21] V. Y., Bykov, O. Y., Burov, L. A., Luparenko, O. P., Pinchuk, & A. V. Yatsyshyn, Conceptual foundations for creating the "Ukrainian Electronic Encyclopedia of Education". In: Physical and Mathematical Education, 4(36), (2022). 7-15.
[22] J. Rogushina, I. Grishanova, Ontological methods and tools for semantic extension of the MediaWiki technology. In: Proc. of the 12th International Scientific and Practical Conference of Programming UkrPROG, CEUR Workshoop Proceedings, 2021, Vol-2866, pp.61-73.