Impact of the Skills4EOSC Project on Bulgarian Open Science

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Abstract. Open Science (OS) is a global movement that transforms the way research is conducted, shared, and utilised by promoting transparency, accessibility, and collaboration. Bulgaria has embraced these principles by implementing policies and practices aligned with European frameworks to facilitate Open Access, FAIR (Findable, Accessible, Interoperable, and Reusable) data management, and collaborative research infrastructures. As a member of the European Open Science Cloud Steering Board, Bulgaria showcases its commitment to building a European ecosystem for OS. It urges national research communities to engage in European initiatives such as Openaire, NI4OS-Europe and Skills4eosc. These initiatives seek to establish the foundations of OS by sharing scientific knowledge products (research articles, data, and software) and actively participating in the process of knowledge production (citizen science, crowdsourcing). This paper presents Bulgaria's participation in the Skills4EOSC project, the benefits of the project for advancing Open Science in Bulgaria, and its contribution to the country's integration into the European Research Area.

Keywords: Open Science, FAIR Principles, Skills4EOSC Project, Training Ecosystem.

1 Introduction

1.1 Open Science

Open Science is a set of values, principles, and practices that aims to make scientific research from all fields accessible to everyone. Its core concepts include fairness, integrity, impact, and the free sharing and conduct of research. The primary tenet of open science is that scientific results - publications, data, software, and methodologies - should be made available to the public, including researchers, policymakers, citizens, and others. This approach fosters reproducibility, innovation, and public engagement.

There are six principles of open science: open methodology, open source, open data, open access, open peer review, and open educational resources.

The FAIR principles in Open Science emphasise three main types of objects: data (any digital object), metadata (information about that object), and infrastructure. The key principles established to maximize the potential for research data reuse include Findability, Accessibility, Interoperability, and Reusability. These principles assist researchers in making their data easier to discover, access, interact with, and reuse. This fosters equality in access to research and enhances global collaboration (EC Expert Group on Turning FAIR Data into Reality, 2018). This can only be achieved if barriers to knowledge are removed, such as legal and licensing restrictions, cultural and institutional barriers, and a lack of infrastructure.

On one hand, Open Science supports the development and dissemination of academic knowledge; on the other hand, it plays a key role in solving important societal problems, such as climate change, public health crises, and combating disinformation. Open Science helps transform scientific discoveries into practical solutions. Its inclusion in national and regional research strategies underlines its importance as a driver of innovation and economic growth (OECD-Making Open Science a Reality, 2015).

1.2 European Open Science Cloud (EOSC)

A key initiative of the European Commission is the creation of a transformative research ecosystem in Europe - the European Open Science Cloud (EOSC) (EOSC-webpage, 2025). Its mission is to provide an open and integrated environment for accessing, managing, and sharing scientific data and services. EOSC provides an infrastructure that connects research institutions, data repositories, and computing resources, creating conditions for more efficient and collaborative science (EOSC Secretariat, 2022). The main objectives and features of EOSC are related to:

1) **Creating a centralized data and services infrastructure.** This aims to unify various national and regional infrastructures, thereby ensuring equitable access to data, methodologies, and computing resources (EOSC Association, 2023).
2) **Implementing FAIR principles.** In this way, standards are maintained that ensure discoverability, accessibility, interoperability, and re-use of scientific data (Wilkinson, M.D., Dumontier, M., Aalbersberg, I. et al., 2016).
3) **Promoting interdisciplinary and cross-border research.** This allows for the facilitation of the sharing of data and resources between different scientific fields and between EU Member States.
4) **Promoting innovation,** thus ensuring open access to scientific results to help industry and society develop new products and services (Plan, 2019).

1.2.1. Bulgaria's Commitment to Open Science and its Role in EOSC

Bulgaria is strongly committed to the development of Open Science practices by adapting national research policies to the European Open Science Framework. With the adoption of the National Open Science Plan (2021-2027) (Bulgarian National Open Science Plan, 2021) and participation in key initiatives such as NI4OS-Europe (NI4OS-

official site, 2025) and Skills4EOSC (Skills4EOSC-official webpage, 2025), the country is taking steps to integrate the principles of transparency, accessibility, and collaboration into its research activities. Leading institutions, such as the Bulgarian Academy of Sciences (BAS) and many universities, are actively adopting open access policies and the FAIR data principles.

The ***Open Data and Cloud Computing Nitional Iniciative*** (ODCC NI, 2021) (Toli, 2021) was established in December 2021 by 9 research organizations to create:

- Synergies at the national level between organizations with a role and interest in the EOSC.
- Integration of open data infrastructures (storage) and cloud computing (services and resources) in the EOSC.
- Supporting activities to optimize services for research and innovation.
- Sharing and disseminating information about the participants' infrastructure, services, and expertise, as well as their work and achievements.

The coordinating organization of the initiative is the Institute of Information and Communication Technologies, Bulgarian Academy of Sciences and the partners are Sofia University "St. Kliment Ohridski", Technical University – Sofia, Medical University – Sofia, University of Plovdiv "Paisii Hilendarski", University of Library Studies and Information Technologies – Sofia, Institute of Mathematics and Informatics - BAS, National Institute of Geophysics, Geodesy and Geography - BAS, Institute of Mechanics – BAS.

Bulgaria's participation in the EOSC creates opportunities for access to European research resources and data. This is for the advancement of science by expanding capacity, providing training, and encouraging a collaborative community. In addition, the country's participation in EOSC accelerates innovations that support economic and social impact (Plan, 2019).

2 Overview of the Skills4EOSC Project

The European Skills4EOSC ("*Skills for the European Open Science Commons: creating a learning ecosystem for Open and FAIR Science*") project, coordinated by GARR and funded under the Horizon Europe Framework Programme, was launched in 2022 (Horizon Europe work programmes 2023-2024, 2024). Its main objective is to create a pan-European network of competence centers to accelerate the training of European researchers and improve the training of new specialists in scientific data management. The consortium brings together 44 partners from 18 European countries, including Italy, the Netherlands, France, Finland, Denmark, Norway, Greece, Bulgaria, Serbia, North Macedonia, Germany, Belgium, Austria, Poland, Sweden, Estonia, Spain, and the United Kingdom. These partners represent national, regional, institutional, and thematic competence centers in the field of open science and scientific data management. The main objectives of the project are related to:

1. Mapping career profiles related to Open Science and defining, through co-creation, the "Minimum Viable Skills Set" (MVS) for each of them. Creating a shared framework for the recognition of competences acquired by students,

trainers, and new professionals as part of an academic pathway or lifelong learning process.

2. Defining a methodology and quality assurance process to guarantee the quality and relevance of Open Science learning materials and the management of their life cycle, thus improving their re-use.
3. Offer training on open science and the use of data in evidence-based policy for civil servants and policymakers, empowering competence centers, researchers, and "honest brokers" by offering resources to deliver training for this purpose.
4. Define "Essentials for Open Science and Data-intensive Science" for inclusion in common undergraduate, postgraduate, and doctoral curricula as a key skill that everyone doing research is expected to acquire.
5. Design and implement a model of collaboration between national and regional competence centers and international research infrastructures and communities to provide specialized open science competences targeted at the needs of researchers and thematic professional research infrastructures.
6. Support lifelong learning through professional networks as a conducive environment for discussion, co-creation, and exchange of best practices and solutions between professionals and researchers.
7. Coordinate national, regional, and thematic competence centres on Open Science and EOSC in Europe and use their expertise to create a widespread user support network and an environment that promotes and harmonises training and skills activities.
8. Create and implement an engagement strategy with relevant stakeholders to co-create and promote project outputs (curricula, shared certification and quality assurance frameworks, human networks), and build partnerships to embed project activities and results among the widest network of stakeholders.
9. Establish synergies with key actors in the Member States and the EOSC scene, as well as with human capital and training programs at the national, regional, and European level, to maximize the impact of project activities and results and pave the way for their long-term sustainability.

These intentions contribute to building a well-prepared digital workforce that seeks to support and sustain the objectives of the EOSC.

3 Impact of the Skills4EOSC Project on Bulgarian Open Science

3.1 Implementation of FAIR Data

Bulgaria has made significant progress in implementing the FAIR principles by developing and applying tools and methodologies that guide and facilitate data management and reuse according to international standards. Resources have been created to enable researchers to prepare Data Management Plans (DMPs) and improve the accessibility and interoperability of data management. The rationale behind Bulgaria's management of the implementation and application of FAIR best practices

on data is that these practices are already being implemented in the European Research Area (ERA) (European research area, 2025).

3.2 Infrastructure Development

The Skills4EOSC project supports Bulgaria's successful integration into the EOSC. It ensures that research results are compatible with international standards. The development of national data repositories and platforms (e.g. National Open Science Portal (BPOS) (Bulgarian Portal for Open Science, 2025), National Centre for Information and Documentation (NACID) (National Centre for Information and Documentation (NACID, BG), 2025), Bulgarian Digital Mathematics Library (BulDML) at IMI-BAS (BulDML at IMI-BAS, 2025), and others are related to the integration of Bulgaria into European open science. These platforms provide a secure and accessible environment for storing, sharing, and reusing data, while promoting transparency and collaboration - the main principles of open science.

The collaboration between the Skills4EOSC project and the ODCC NI (ODCC NI, 2021) has been particularly successful. The main activities within this cooperation are: (i) Identifying digital resources and standard thematic cloud services owned by the partners; (ii) Developing and providing training materials on open data and cloud computing to the academic community; (iii) offering technical assistance for compliance with EOSC requirements; (iv) Promoting the EOSC and FAIR principles and their adoption by scientific data providers; (v) Organising webinars and seminars for doctoral students and young scientists. These initiatives contribute to the development of sustainable infrastructures and capacities necessary for advancing open science in Bulgaria.

The good news for researchers who need access to a data storage system is that, over the last two years, members of the initiative, through their participation in projects funded by the Operational Program “Science and Education for Smart Growth,” have acquired a significant amount of new equipment with substantial data capacity. The largest facility is the new infrastructure complex in IICT, which includes the supercomputer HEMUS with a peak performance of more than 3 Peta Flpops (HEMUS-Top500, 2024) of the most powerful supercomputers in the world, a data storage and processing system with a capacity of more than 6.72 Peta Bytes, and high-performance server systems for application development and digitization facilities. For an efficient and convenient user experience, all layers of the computing ecosystem are well integrated, including the network, computing resources, data, software, services, and tools.

3.3 Cooperation and Networking

Bulgaria’s active participation in international initiatives, such as the NI4OS-Europe (NI4OS-official site, 2025) and Skills4EOSC projects (Skills4EOSC-official webpage, 2025) , contributes to exchanging good practices with other European countries. In this way, the country builds strategic partnerships that support cooperation within the EOSC framework. By promoting such international networks for knowledge and innovation exchange, European countries, including Bulgaria, contribute to the creation of a coherent and inclusive European ecosystem for open science. Through the

Skills4EOSC collaboration, Bulgarian stakeholders completed the online "Open Science and Evidence-Based Decision Making Course" curriculum (OSE_BDM Course, 2024), which included seven courses held between October and December 2024. Additional representatives of the Bulgarian Open Science community participated in the workshop "Science4Policy - Bridging the gap between research and decision-making", held in Rome, Italy (Science4Policy, 2025).

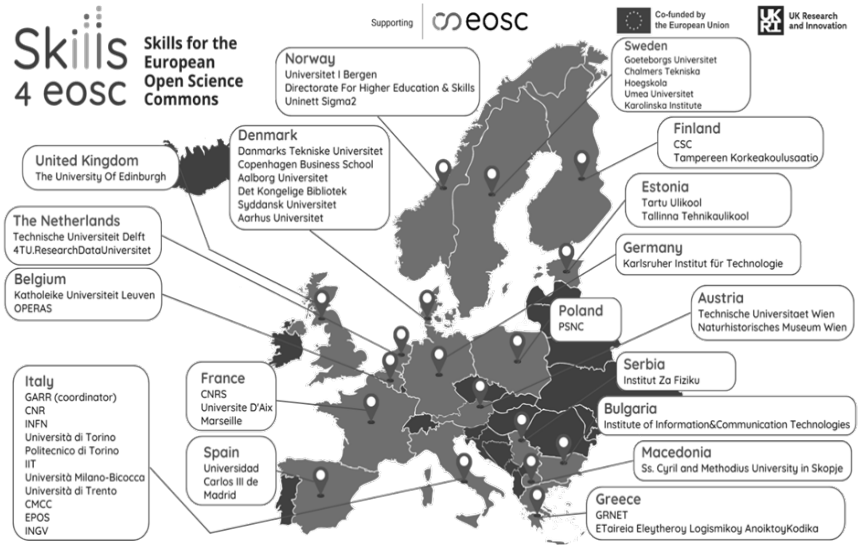

Fig. 1. A map of the 18 European countries participating in the Skills4EOSC project (Skills4EOSC-official webpage, 2025).

3.4 Capacity Building

One of Bulgaria's key activities within the Skills4EOSC project is the organization of trainings and seminars that are oriented toward the development of core skills in FAIR data management, open-access publishing, and collaborative research (Skills4EOSC Training Courses, 2025). In this way, the competencies of researchers are improved and the institutional capacity of universities and research organizations is strengthened. This contributes to the active participation of Bulgarian scientists in international research projects and contributes to the development of open science in Europe.

3.5 Contribution to Learning Ecosystems

Through the Skills4EOSC project, the country contributes significantly by creating localized training programs and materials adapted to the specific needs of Bulgarian researchers and institutions. The achievements that the country has achieved are related to the following activities:

1) **Educational programs**

For the specific needs of the Bulgarian scientific community, the Skills4EOSC project develops educational materials (resources) related to the concept of open science and the FAIR principles, which leading universities, such as Sofia University, can integrate into their curricula.

2) Training of Trainers (ToT)

One of the main activities of the project is the conduct of specialized trainings for trainers, who aim to create a network of competent individuals in open science. These initiatives provoke the participation of a wide range of stakeholders.

3) Platforms and digital tools

Using the FAIR principles, national repositories and tools for scientific data management have been developed, thus supporting both teaching and research activities.

4) Competence Centres

The establishment of competence centers is an important tool for knowledge sharing and capacity building. Bulgaria's participation in its establishment contributes to the dissemination of training aimed at researchers, data administrators, and policymakers, thus building a new generation of specialists to work within the European open science ecosystem.

Bulgaria participates in the organization of activities and events, such as:

i. National conferences and forums

Events such as the National Information Day: "Open Science, Open Data and Cloud Computing" Open Science Day (NID, 2024) are held annually and aim to track progress on the implementation of the concept of open science and the FAIR principles. These forums allow scientists, institutions, and citizens to actively participate in a discussion on the future of science.

ii. Participation in international projects

Bulgaria hosts regional seminars and workshops within initiatives such as NI4OS-Europe. Bulgarian researchers and politicians actively participate in European events such as the EOSC symposium.

iii. Training and workshops

The organization of specialized trainings and seminars on FAIR data management and the use of EOSC services aimed at researchers, politicians, and administrators increases the competencies of the various target groups.

Through these activities, Bulgaria demonstrates a strong commitment to the development and dissemination of the concept of open science. Its active participation in international networks, trainings, and infrastructure projects strengthens its position in open science and knowledge sharing.

3.6 Long-term Benefits

Bulgaria's participation in the Skills4EOSC project contributes to strengthening its place in the European research ecosystem. This opens up new opportunities for funding, projects, and global visibility of scientific research for our country. The integration of open science accelerates innovation and contributes to the development of technology, healthcare, and sustainable development, which has a positive impact on the economy and quality of life.

4 Challenges and Opportunities

4.1 Ongoing Challenges

Despite Bulgaria's participation in various initiatives such as NI4OS-Europe and Skills4EOSC, the country faces challenges in realizing the full potential of open science. One important issue that European countries face is the sustainability of training programs and infrastructure. Maintaining and updating them requires long-term funding and institutional commitment, which can be difficult to secure. Another barrier is related to institutional resistance to the adoption of open science practices, which is caused by concerns about resource allocation, intellectual property, and lack of awareness. Overcoming these challenges requires both technical support, but also cultural change and active engagement of the scientific community and political institutions.

4.2 Opportunities for Growth

Regardless of the challenges that Bulgaria faces, the country has significant opportunities to improve its role in the European Open Science ecosystem. One example is funding mechanisms through programmes such as Horizon Europe and the EOSC initiatives, which can support the further development of national infrastructure, training programmes, and international cooperation. If Bulgaria uses its experience from participating in projects such as NI4OS-Europe and Skills4EOSC, the country can establish itself as a hub for innovation in open science in South-Eastern Europe. This position would improve the country's visibility in the European research community, as well as attract multiple partnerships and investments.

5 Future Directions

5.1 Policy Recommendations

To ensure and develop open science, Bulgaria should focus on long-term investments in infrastructure and educational programs. Stakeholders, such as the national government and research institutions, should prioritize funding related to the expansion and maintenance of data repositories, collaborative platforms, and training initiatives created within projects such as Skills4EOSC. In parallel, viable national strategies should be developed and aligned with the European goals for Open Science, in particular the EOSC. To overcome local challenges, it is necessary to create policies that promote cultural change and the adoption of Open Science practices.

5.2 Vision for Open Science in Bulgaria

In the future, Bulgaria's vision for open science should focus on deepening its integration into the EOSC and other European research networks. On the one hand, if Bulgaria manages to contribute to the sharing of infrastructures and services, it will be able to consolidate its role in the European research ecosystem. On the other hand, it is essential to promote the culture of open science among Bulgarian academia, industry, and stakeholders, as this will lead to higher public engagement with scientific achievements related to solving important societal problems.

6 Conclusion

With Bulgaria's active participation in Open Science projects such as NI4OS-Europe and Skills4EOSC, along with investments in educational ecosystems, the establishment of competence centres, and the implementation of FAIR data principles, the country demonstrates a clear commitment to integrating into the EOSC. Its involvement in European scientific networks and the utilisation of shared resources facilitates access to innovative technologies, enhancing its researchers' qualifications and strengthening its position within the European scientific ecosystem. In the future, Bulgaria has significant potential to establish itself as a regional leader in Open Science. By building on its achievements and overcoming the challenges it faces, Bulgaria can become a model for successful integration into the European research environment. The combined efforts of the government, the academic community, and industry to implement open science principles will contribute not only to the country's scientific and economic growth but also to the development of fairer and more impactful scientific practices on a global scale.

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