Towards Promoting the Culture of Sharing: Using Blockchain and Artificial Intelligence in an Open Science Platform

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Abstract

Several studies in the literature have proposed the use of artificial intelligence (AI) tools to manage big data and further enhance collaboration between researchers on open science platforms, hence promoting the culture of safely sharing reliable data. Moreover, some other studies further proposed the use of blockchain technology to secure data, provide transparency in data analysis, and also keep track of all collaborations within open science platforms. Despite the importance of AI and blockchain technology in open science platforms, no study, to the best of our knowledge, has implemented and discussed the benefits of using both technologies together or how blockchain can enhance AI systems in open science. Therefore, to address this research gap, this study presents a newly developed open science platform that harnesses the power of AI and blockchain technologies to promote and foster a culture of sharing and seamless collaboration among universities worldwide. This platform was then validated through focus group analysis from the European University for Customised Education (EUNICE) partners, which is the project context of this present study. The findings revealed that the use of AI and blockchain enabled researchers and institutions to share open science more effectively. Specifically, the use of AI features in Open REUNICE enhanced data management processes, particularly by improving metadata accuracy, searchability and reusability, thereby addressing critical needs in research workflows. Additionally, the use of Blockchain was found to play a critical role in addressing legal challenges and enhancing user trust.

Keywords

Artificial Intelligence, Big Data, Blockchain, Culture of Sharing, Open Science.

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I. Introduction

Open science is a movement that aims to make scientific research and data accessible to everyone, regardless of their background or affiliation. It involves the sharing of research data, software, and methods, as well as the promotion of transparency and collaboration in scientific research [1]. It has gained significant momentum in recent years as a powerful approach to enhance the quality, efficiency, and impact of scientific research. Consequently, numerous universities worldwide have incorporated open science into their strategic plans to elevate the quality and influence of their research efforts [2]. The open sharing of knowledge has thus become central to the academic process. However, fostering a culture of data sharing requires cooperation between data generators and data users. Moreover, effective sharing requires the establishment of protocols to maintain a comprehensive data history and address the concerns of data generators regarding recognition for their rigorous work, such as authorship attribution [3]. Thus, the provision of an effective open science infrastructure, capable of addressing these concerns comprehensively, is paramount.

A review on open science conducted by Leible et al. [4] identified a list of specific requirements that should be fulfilled in any open science infrastructure, namely: a collaborative environment, open data, open access, no censorship, identity and reputation management, and an extensive system. Integrating these elements is crucial for building an effective and sustainable open science framework that supports and enhances the collaborative nature of modern scientific research.

On the other hand, several challenges related to the implementation of open science practices have been identified in the literature. For instance, open science generates a large volume of data from various stakeholders, including researchers, non-academic actors, and citizens, leading to potential issues with data duplication and the validity of published data. According to Fecher and Friesike [5], managing the quality and trustworthiness of open data remains a significant challenge. Similarly, Borgman [6] highlights the complexities involved

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in curating and validating the vast amounts of data produced in open science initiatives. Additionally, the involvement of multiple stakeholders can complicate the data curation process, as discussed by Tenopir et al. [7], who emphasize the need for robust data management practices to ensure the reliability of open science outputs.

Furthermore, several data sharing problems have been identified in the literature, specifically regarding the sharing of personal data, such as medical information and personality-related data [8]. One of the main objectives of open science is to improve collaboration between academic and non-academic stakeholders; however, there is often a lack of traceability regarding the contributions of collaborators [3]. This challenge of traceability is also identified for data analysis, where ensuring the accuracy and provenance of data remains a significant concern.

To improve open science practices, several studies in the literature highlighted the potential of AI and blockchain technologies. For instance, AI can make science more open and accessible by improving data management and facilitating more efficient research workflows [9]. Specifically, AI can be used to analyse large datasets, predict outcomes, identify patterns, and automate repetitive tasks. AI can facilitate interdisciplinary collaborations between scientists from different fields, leading to novel insights and discoveries that would otherwise have been difficult to achieve. Furthermore, generative AI using large language models (LLM) can help scientists generate new research questions and hypotheses [10].

Blockchain, on the other hand, was proposed to track the traceability of researchers' contributions in collaborative projects, thereby ensuring transparency and accountability [11]. Blockchain was also proposed to overcome AI related challenges, such as interpretability issues in AI models [12]. However, despite the importance of blockchain and AI, no study, to the best of our knowledge, has implemented and discussed the benefits of combining these two technologies in one online platform, including open science platforms [13]. Accordingly, it is hypothesised that the combination of AI and blockchain would enable researchers and institutions to share open science more effectively. To investigate this hypothesis, the present study presents a newly developed open science platform, namely OPEN REUNICE, that harnesses the power of AI and blockchain technologies to promote and foster a culture of sharing and seamless collaboration among researchers. Specifically, this study aims to answer the following research questions (RQs):

RQ1. How users perceive the developed features in the OPEN REUNICE platform?

RQ2. How can the OPEN REUNICE platform address open science challenges, such as data management issues and legal obstacles in the literature?

The rest of the paper is organized as follows. Section II discusses the background of open science and its limitations, AI and blockchain technology. Section III presents the description of the implemented open science platform. Section IV presents the methodology of the study. Section V presents and discusses the results. Finally, section VI concludes the paper.

II. Literature Review

A. Open Science

Four categories of activities that rely on open science were proposed by the United Nations Educational, Scientific and Cultural Organization (UNESCO) [1], namely: (1) open science knowledge, which refers to open access to scientific publications, open research data, open educational resources, open source software and source code, and hardware that are available in the public domain or under copyright and licensed under an open license; (2) open science infrastructures which refers to virtual and physical infrastructures used for sharing data, collaboration and digital research services; (3) open engagement of societal actors refers to extended collaboration between scientists and members of the public outside of the scientific community by applying citizen and participatory science, crowdsourcing, crowdfunding, and scientific volunteering; and, (4) open dialogue with other knowledge systems, which refers to the dialogue between different knowledge holders, such as indigenous peoples, marginalised scholars, local communities. Each of these categories focuses on a different aspect of open science, with the goal of promoting the values of openness, transparency, and collaboration in scientific research. Open science is increasingly associated with FAIR (Findable, Accessible, Interoperable, and Reusable) principles to ensure that science resources have the necessary metadata to make them findable, accessible, interoperable, and reusable [14].

Several problems related to the implementation of open science, specifically with data sharing were identified in the literature. For instance, Zhou [15] found that Lack of trust, lack of a conducive knowledge sharing culture, Lack of strong knowledge sharing leadership, and cultural affinity for autonomy are from the main obstacles of data sharing. Zuiderwijk et al. [16] argued that an online infrastructure to support the provision and use of open data must include specific features, which can be categorized as follows: (1) Data Provision which includes the acquisition of data and metadata, along with their validation and enhancement; (2) Data Retrieval and Use which includes the display of data and its retrieval through query mechanisms; (3) Data Linking which refers to the establishment of connections between datasets using metadata, which can be done automatically or manually; (4) User Rating which refers to rating users' contributions on the platform as well as their publications; and, (5) User Cooperation which refers to understanding users' preferences, responsibilities, and behaviours. Specifically, some of these features can be achieved using AI, such as data linking to find similar works and user cooperation to understand users' behaviours [17]. Consequently, the subsequent section will discuss how AI can be leveraged to overcome certain limitations of open science, enhancing collaboration and data integration.

B. Artificial Intelligence

AI was broadly described by Baker and Smith [18] as "computers which perform cognitive tasks, usually associated with human minds, particularly learning and problem-solving" (p.10). According to this definition, AI encompasses a wide range of tools and techniques, including machine learning, data mining, neural networks, natural language processing (NLP), and numerous algorithms.

AI plays a pivotal role in revolutionizing open science by offering innovative solutions to address the challenges associated with data management, analysis, and collaboration. Notably, machine learning tools, data visualization, and intelligent decision-making are among the most commonly used AI techniques in open science [19]. For instance, machine learning algorithms have been instrumental in automating data processing tasks, enabling researchers to sift through vast datasets efficiently. Moreover, AI-driven tools contribute to enhancing reproducibility by automating experimental workflows and aiding in the validation of scientific findings [20]. The utilization of AI fosters greater transparency and accessibility, allowing researchers to share data, methodologies, and results seamlessly. Gundersen et al. [20] also claimed that the use of AI to generate sufficient documentation for publications, such as basic metadata (title, abstract, keywords, etc.) and digital object identifier (DOI) or URL to ensure permanent accessibility, can facilitate reproducibility in research. Similarly, Patra et al. [17] found that AI can help in generating accurate metadata, which enhances the effectiveness of dataset recommendations in open science platform. A study by Olivetti et al. [21] explores the application of NLP in scientific literature demonstrating how AI tools can facilitate the extraction and synthesis of information from a vast corpus of scholarly articles, further promoting open access to knowledge. Furthermore, Bail [22] discussed the use of generative AI to identify novel research questions, since it was capable of providing a broad perspective on many different scientific fields. These advancements underscore the transformative impact of AI on open science, paving the way for collaborative and data-driven research practices.

The integration of AI into open science, while promising, confronts a range of challenges as discussed in the existing literature. For instance, ethical considerations regarding the responsible use of AI, particularly in handling sensitive data, were highlighted by Mittelstadt et al. [23] who emphasize the importance of addressing ethical concerns to maintain trust in AI applications. Interpretability issues in AI models, commonly referred to as the "black-box" problem, are articulated by many researchers, underscoring the need for transparent and explainable AI systems in open science [24] [25] [26]. Interoperability challenges are discussed by Mons et al. [27], emphasizing the necessity for standardized data formats and tools to facilitate seamless collaboration across diverse research environments. The demand for substantial computational resources and expertise is acknowledged by Amodei et al. [28], indicating potential barriers to the widespread adoption of AI in open science. Furthermore, security attacks on data and learning algorithms in AI based open science platforms were highlighted by Shinde et al. [29]. In order to overcome the identified AI challenges, several studies in the literature proposed the use of blockchain technology. The next subsequent section presents the blockchain technology and its benefits and challenges.

C. Blockchain

Blockchain is a secured distributed ledger technology that ensures the security and reliability of transactions by providing a digital record of every transaction that has ever taken place on the network [30] [11]. Blockchain organizes its data into blocks that are cryptographically and chronologically linked together. Additionally, it utilizes various consensus mechanisms and smart contracts [31].

Blockchain has the potential to offer numerous benefits across different fields and applications due to its inherent characteristics, namely decentralization, transparency, immutability, better security, anonymity, cost reduction, and autonomy [24]. In the context of open science, Leible et al. [4] demonstrated that blockchain technology serves as a suitable infrastructure for open science, as the characteristics of blockchain align well with the requirements of open science. For instance, blockchain technology can be used to address reproducibility of findings in published articles and experiments issues [32]. The immutability, append-only functionality, and a transparent log of all transactions inherent in blockchain can offer visibility to all users, ensuring transparency across every step within a system. Additionally, the decentralization empowers researchers to construct their individual open ecosystem for research data, metadata, and communication, aligning with the principles of open science.

Furthermore, blockchain technology has the potential to tackle trust issues related to malicious conduct in peer-review procedures [33], deficiencies in study design quality and redundancy [34], as well as limitations on open access to scientific publications. Additionally, the decentralized characteristics of blockchain enable the enhancement of trust in studies and collaborations within intricate scientific projects. Blockchain technology enables either specific groups or the entire network to collectively make decisions regarding projects through regular voting processes, which may adhere to democratic principles, as exemplified by Osgood [35]. The inherent characteristic of immutability (tamper-proof) in blockchain technology perfectly meets the necessity to prevent any form of censorship in open science. In particular, the combination of cryptographic hashing, a consensus mechanism, and decentralization guarantee the immutability of a blockchain. In the context of projects in open science, blockchain can also safeguard intellectual property rights. For instance, it can issue ownership certifications for digital assets stored in a hashed form on the Bitcoin blockchain, as demonstrated in the Bernstein application [36].

Blockchain distinguishes itself from other decentralized systems through its remarkable technical framework, enabling its adaptation to a diverse range of applications. For instance, developers can tailor blockchains to accommodate either open or private access, incorporating individual governance models based on their specific objectives. Beyond the technical aspect, cryptocurrencies offer distinct opportunities, such as the creation of unique business models and incentives for users or entire communities.

Blockchain can enforce immutability and non-repudiation for information stored on it. Regulation and personal humility often stand in the way of this sharing. Blockchain offers new and novel ways to share data securely with only the providers or researchers who are supposed to receive it. For instance, Yates [37] found that the use of the unique identifier generated by the blockchain for private or sensitive data, like medical data, can enhance data security as only the provider and the receiver can see the document. Tlili et al. [38] highlighted the importance of using blockchain to protect data sharing in open science, specifically when generating new Open Educational Resources.

The next section presents the Open REUNICE platform, which harnesses the power of AI and blockchain technologies.

III. Implementation

An innovative open science platform, Open REUNICE (Open research within EUNICE), was developed (http://reunice4u.com/). Open REUNICE harnesses the power of AI and blockchain technologies to foster seamless collaboration among EUNICE partners. Its goal is to establish an environment where researchers can effortlessly connect, share knowledge, and engage in meaningful collaborations. Particularly, 10 universities and 31626 researchers have joined the platform, where 234028 publications and 26 projects were added, accordingly. This platform met the requirements of the EUNICE alliance. Specifically, the project team organized weekly meetings and followed these steps: (1) study of the current situation of open science in the university's alliance; (2) specification of the needs and discussion of the open science problems faced in the alliance; (3) study of feasible and non-feasible functionalities; (4) conception of the project using different diagrams in Unified Modeling Languages; (5) discussion of the design of functionalities between team members; and finally (6) implementation.

To promote a culture of scientific data sharing, this platform was established based on the FAIR principles of open science [39]. Additionally, it seeks to unify the efforts of all universities within the alliance by aligning their open science strategies and implementing a shared platform, fostering collaboration and ensuring mutual benefit.

Based on the analysis of each researcher's profile on the platform, Open REUNICE provides personalized libraries, containing their own publications as well as pertinent research works from their field of expertise. This feature not only streamlines access to relevant information but also encourages interdisciplinary exploration and the discovery of novel research avenues within the alliance. In this context, AI was implemented to provide more accurate resources on the platform. For instance, natural language processing (NLP) was used to automatically extract keywords from each uploaded resource, analyze them with the research interests of each registered researcher, and finally suggest these resources to those researchers who might be interested in them. Such process helps to build and maintain a research community within Open REUNICE, where researchers could discuss and collaborate on common research topics. Additionally, Blockchain was further used to provide more security and promote the culture of sharing through Open REUNICE. For instance, it gives an identifier for each project, thereby, protecting its intellectual property rights and keeping track of all the updates of contributors. Specifically, the interaction between AI and blockchain on this platform was primarily focused on data management. Blockchain was employed to securely handle and manage the large volumes of data required for training AI models, addressing critical concerns related to data integrity and security [40]. By leveraging blockchain technology, the platform ensures transparent and traceable records of research processes, including AI workflows, data sharing activities, and collaborative efforts. This synergy enhances trust, reproducibility, and accountability in research, aligning with growing calls for more robust frameworks in AI-driven applications [41].

Fig. 1 presents the architecture of Open REUNICE. The system's workflow is color-coded to highlight its key components and processes. Specifically, the red lines represent the process of data collection from various databases and the community-building activities described in detail below. The blue lines depict the analysis process of researchers' publications and projects using AI techniques. Data collected about researchers are stored in the system database, while the outputs of AI-driven analysis—such as extracted keywords and identified research communities—are securely stored on the blockchain to ensure data integrity and security. Finally, the green lines illustrate the safeguarding process for projects. Specifically, all projects are stored on the blockchain system to protect researchers' intellectual property rights and to maintain a transparent record of all contributor updates and changes.

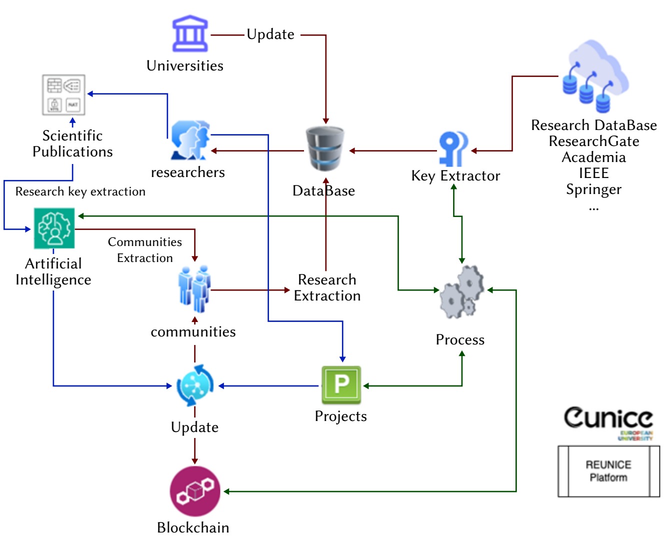

Fig. 1. Open REUNICE platform architecture.

The development process of Open REUNICE was divided into the following four key sequential steps.

A. Data Collection

Open REUNICE uses an application programming interface (API) to extract data about researchers and their publications from ResearchGate, establishing a primary database sourced from research websites. Currently, the platform extracts data from ResearchGate, with plans to expand its connectivity to other research databases for further information updates in the future (Other APIs can also be added to retrieve more complete representation of researcher's publication history). Specifically, for legal concerns, we consider collecting metadata about publications from ResearchGate and provide links back to the original ResearchGate pages.

Fig. 2 shows the Open REUNICE dashboard of the data collected, illustrating the total number of researchers added to the platform, the contributions made by participants, and the most frequently addressed research topics, from an administrator view point. This comprehensive overview highlights the platform's growth, user engagement, and research focus areas, offering valuable insights into the active involvement of the research community and the trending topics within the platform.

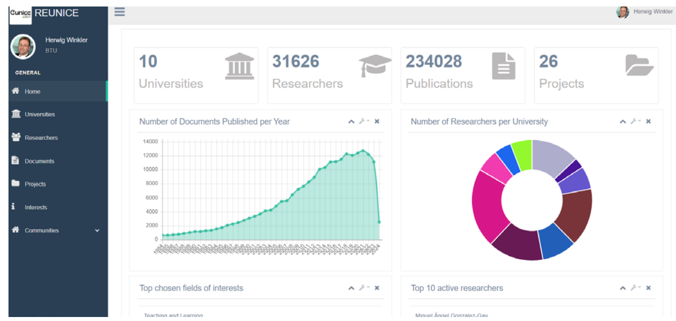

Fig. 2. Screenshot of the dashboard.

B. Building Scientific Community

The researchers' database was constructed based on the collected data from the first step. Specifically, we incorporated information about researchers (university, department, research interests, and publications) into Open REUNICE to create their profiles. Once they join, researchers can update their information and add more publications or projects that they want to share with others. To prevent confusion caused by identical names, researchers' unique identifiers, specifically their open researcher and contributor ID (ORCID), is included in their profiles. The identification of a researcher's ORCID can be done automatically using their email, or manually by the researcher. All collected data about researchers and their research were used by AI to improve collaborations on the platform, as discussed in the next section.

C. Use of AI to Enhance Collaborations and Create Connections

To promote the culture of sharing among researchers from various universities, Open REUNICE relies on AI techniques, specifically NLP, to analyze extensive publication datasets, extracting valuable insights to enhance research quality and discover new patterns and correlations in research trends and methodologies. Given the diverse document types that can be published on the platform, such as research data, scientific articles, and projects, NLP was used to analyze both titles and full texts of researchers' publications, extracting specific research keywords based on publication content (see Fig. 3). The employed technique relies on the frequency of word occurrences in the text. To do so, the YAKE library (Yet Another Keyword Extractor) has been chosen after several tests. YAKE has been recognized in the literature for its efficiency in unsupervised keyword extraction by leveraging statistical text features, such as term frequency, position in the text, and co-occurrence metrics, to identify significant terms without relying on external corpora [42]. The text analysis allows extracting accurate metadata, identifying similarities between publications using these keywords, and categorizing them based on research interests. Specifically, for similarity detection, this platform employs the Generative Pre-Trained Transformer (GPT-3.5-turbo) model as a pilot test. This model offers a compelling balance of performance and efficiency, aligning with findings in the literature that emphasize the capability of large language models to deliver high accuracy in semantic similarity tasks [43]. Furthermore, GPT-3.5-turbo is designed to be computationally optimized, resulting in lower operational costs and reduced environmental impact compared to earlier iterations of similar models [44].

Furthermore, an AI-based notification system was implemented to inform researchers about new publications and projects on the platform that align with their identified research interests. This system generates automatic recommendations for potential project collaborations. Specifically, if the extracted key words of the new publications and projects match with the keywords of the researcher's publication, a notification will be sent to the researcher. AI was also used to suggest the creation of communities based on matching research interests. This allows creating communities and inviting researchers working on similar topics to join, fostering collaboration and enhancing the overall research environment. This approach not only streamlines the discovery and retrieval of relevant research content but also promotes a more connected and collaborative research community.

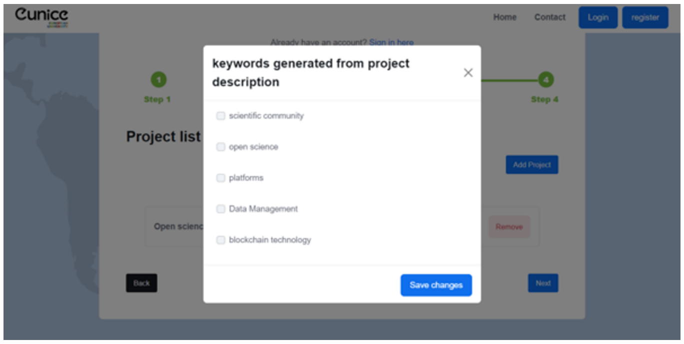

Fig. 3. Screenshots of keyword extraction using NLP.

D. Use of Blockchain to Secure Research Projects Management

To protect intellectual property rights associated with published projects, new ideas, and research data, Open REUNICE was built based on a private Ethereum blockchain. Specifically, it was built using Geth to establish a private network, ensuring the security of all shared data and copyright. In this context, blockchain technology was utilized to issue ownership certificates (in the form of cryptographic hashes) for each project or idea, ensuring secure and verifiable proof of ownership. Fig. 4 presents an example of a project with blockchain reference highlighted in yellow. Blockchain can safeguard researchers' work, ensuring proper attribution and protection against unauthorized use. In addition, each update in the idea by the creator or other contributors is saved in the blockchain to keep track regarding each update (what have been changed). Furthermore, to enhance collaboration, we implemented secure smart contracts on the blockchain to automate and enforce agreements and collaborations about projects among researchers. This reduces administrative overhead and ensures transparent and trustful collaboration. OPEN REUNICE also provides a workspace below the project description where users can leave comments and engage in discussions about the ideas and tasks. Collaborating on projects in a blockchain-based platform allows ensuring the verifiability and persistence of researchers' contributions.

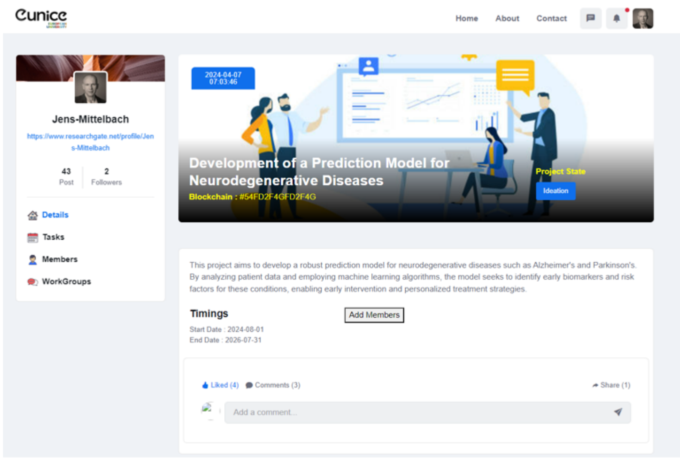

Fig. 4. Screenshot of a project space with blockchain reference highlighted in yellow.

IV. Method

A. Participants and Procedure

Three focus groups with 54 participants were run between 4 June and 25 August 2024 to validate the implemented platform. The first focus group was online with 10 participants, where each participant is a representative from each university of the Alliance. The second focus group with 38 participants, including the 10 participants who assisted in the first focus group, was face to face during the general assembly of the project and it was more open to other researchers from the Alliance. The last focus group was with a sample of 16 active researchers who have used OPEN REUNICE to add their research work and establish various research discussions and collaborations on the platform. Participants were all adults and living or working in European universities. Table I presents the demographic details of participants.

The experiment started with a short presentation of the platform, during which we demonstrated all its functionalities. After that, the first focus group spent around 60 minutes trying and discussing the platform using Zoom, while the second and third focus groups spent around 120 minutes doing the same face-to-face. Even after the controlled experiment concluded, some participants continued to actively use the platform and shared their valuable feedback via email.

TABLE I. Demographic Details of Participants

Characteristics		N (%)
Gender	Male	18 (33)
	Female	36 (67)
Age	25-35	29 (54)
	35-55	25 (46)
Ethnicity	White-Europe	48 (89)
	White-any other white background	6 (11)
Occupational classification	Researcher	38 (70)
	Administrative occupation	16 (30)

B. Data Collection and Analysis

For data collection, a focus group discussion was conducted, which is a systematic process of collecting data and information on a very specific problem using structured, semi-structured, or unstructured interviews through group discussions [45] [46]. A set of questions was used to facilitate the focus group discussion: (1) "How effectively does the platform support your research or assist you in finding collaborators working on similar research topics?", (2) "Which features of the platform did you find most useful for your work?", (3) "To what extent do you trust the platform for sharing your innovative ideas and projects?", and (4) "What improvements or additional features would you like to see on the platform?". Specifically, for the online focus group, the session was recorded and transcribed to identify a coding scheme for analyzing focus group interactions, developed by two researchers. After that, collected data was analyzed and coded using this scheme. The coding scheme was further discussed and developed with other researchers during face-to-face research group meetings. The identified codes were refined to answer the aforementioned research questions.

To evaluate the EUNICE community's readiness, we analyzed their attitudes, infrastructure, training, and constraints. The results indicated that EUNICE community has large experience with open science knowledge practices, such as open data and open access, as well as they have all used open science infrastructures, specifically their institutional repositories [39].

V. Results and Discussion

This section presents the results based on the two research questions presented in section I. Specifically, the discussion of the results was based on the benefits of using AI and blockchain in open science platform since no study, to the best of our knowledge, has implemented and discussed the benefits of combining these two technologies in one online platform.

A. RQ1: How Users Perceive the Developed Features in the OPEN EUNICE Platform?

The results showed that overall the participants have positive perceptions toward the implemented features in Open REUNICE. Specifically, the results showed that most of the participants found that all the functionalities are clear, especially researchers. However, some of them highlighted some difficulties in using the platform, specifically in understanding the AI related functionalities. This can be explained by the lack of experience with AI-based open science frameworks, such as semantic scholar, and knowledge in AI technology as many participants are not familiar with computer science and have not received adequate prior training in advance. In this context, several studies stressed the importance of AI literacy for a better use of AI powered technologies [47]. Therefore, it is crucial to provide more training on cutting edge technologies to develop the skills of EUNICE university stakeholders in using Open REUNICE. This strategy aligns with the European Open Science Cloud's (EOSC) comprehensive skills and education strategy, which includes a focus on artificial intelligence [48]. The European Commission's report on digital skills for open science also highlighted the importance of aligning skills with the new Digital Skills Europe objectives. Specifically, the report emphasized that digital skills for FAIR and open science are key enablers for implementing the new European Research Area [48].

Many participants also noted that the use of blockchain technology within the platform was highly beneficial for securely sharing their publications with researchers from other European universities. Additionally, they found it valuable for gaining a comprehensive overview of researchers working on similar topics, their publications, and relevant calls for projects. This enhanced connectivity and transparency not only facilitated collaboration but also fostered a sense of trust and engagement within the research community. Participants emphasized that the platform has the potential to significantly increase the visibility and impact of their publications by sharing them with a wider network of European researchers. Furthermore, it offers opportunities to collaborate and build communities centered around specific topics of interest. This aligns with the findings of Davis et al. [49], who stated that researchers' perceptions of the value offered by a platform's services play a critical role in shaping their intention to continue using it in the future.

The integration of AI and blockchain features in Open REUNICE encouraged research participants to use it more than one time for sharing their publications. They even indicated an interest in integrating it into their daily activities due to the platform's social features. Users can communicate with others via instant messages, build their own network of friends, view the latest publications from researchers, and use the collaborative workspace to discuss ideas and projects. This result is consistent with the objective of the previous study of Davis et al. [49], which advocate for changing the perception of open science platforms from simple archives to dynamic online homes for materials and collaboration. In this context, the authors claimed that changing the culture of sharing is seen as dependent on changing our view of open science platforms.

B. RQ2: How Can the OPEN REUNICE Platform Address Open Science Challenges, Such as Data Management Issues and Legal Obstacles in the Literature?

One of the primary challenges in open science lies in effective data management and navigating legal issues. This research question explores how Open REUNICE can address these critical challenges, offering potential solutions to enhance the accessibility, security, and compliance of research data within the open science framework.

Results revealed that many participants emphasized the effective use of Open REUNICE in addressing common challenges related to data management, particularly in terms of data findability and reproducibility. For instance, participants appreciated the use of NLP techniques for automatic metadata generation, especially for extracting research keywords directly from publication content. They noted that this approach could produce more accurate metadata, thereby enabling more efficient searches on the platform.

Participants also highlighted that the platform accommodates diverse publication types, including research datasets, scientific articles, and project descriptions, which often have varying structures. This variability can make manual metadata generation challenging. Consequently, many participants valued the platform's AI capabilities for automatically generating metadata based on the content of these documents.

A previous study by Patra et al. [17] also highlighted the challenges of generating automatic metadata for documents with varying structures. To address this issue, they proposed utilizing NLP techniques to generate metadata based on the title and text of the documents. In this context, the literature emphasizes that poor metadata significantly hinders resource retrieval [50]. Furthermore, Leipzig et al. [51] claimed that the generated metadata can affect data reproducibility which can accelerate evaluation and reuse. Another study about Open Educational Resources (OER) found also that the use of AI and NLP techniques can greatly enhance the findability of OER by providing rich and accurate metadata [52].

Additionally, the generated keywords for publications can be generalized and added to a researcher's academic interests, which would aid in creating research communities based on shared interests and provide recommendations based on previous publications. This approach allows researchers to be represented by a set of interests rather than their entire body of work. Many participants believe that such a recommender system could significantly enhance their productivity and expedite further research. In this context, some participants claimed that the proposed research communities for them match with their interests and they were so helpful to discover the European network of a specific topic. A similar study by Patra et al. [17] developed a recommender system based on automatically generated metadata and found that such a system can significantly improve the reusability of datasets in the biomedical domain. These results align with the general consensus that metadata are crucial in supporting the FAIR principles (Findable, Accessible, Interoperable, Reusable), as demonstrated by the FAIR sharing project [51]. These findings confirm that the integrated AI features in Open REUNICE play a significant role in enhancing data management processes, particularly by improving metadata accuracy, searchability and reusability, thereby addressing critical needs in research workflows.

Regarding the second open science-related challenge that the Open REUNICE can address, the participants expressed that they often face legal challenges when sharing their data, including concerns about copyright infringement and misuse of intellectual property. Blockchain technology can partially solve these issues by providing a secure, transparent, and tamper-proof record of all transactions. For instance, the platform can timestamp and securely store records of intellectual property, ensuring that authorship and contributions are indisputable [53]. Therefore, the participants have indicated that their trust level in sharing their research and data has increased, leading to a more inclusive approach of embracing the culture of sharing. As a result, they expressed their readiness to publish their projects and ideas on the Open REUNICE due to the intellectual property protection offered by blockchain. This is consistent with findings in the literature where blockchain has been shown to significantly enhance trust and transparency in collaborative environments [54]. By securing intellectual property rights, blockchain reduces the fear of idea theft and promotes a more collaborative atmosphere. Researchers are more likely to engage with their peers, share innovative ideas, and build upon each other's work.

Overall, these results confirm that the integration of blockchain technology in Open REUNICE plays a critical role in addressing legal challenges and enhancing user trust. This, in turn, facilitates greater engagement with the platform and supports the broader goals of open science. In addition to the open science challenges identified in the literature, many participants claimed that incorporating a social dimension into Open REUNICE could significantly enhance user engagement. They emphasized that features fostering collaboration, networking, and real-time interaction among researchers could encourage users to interact with the platform on a daily basis, making it a more integral part of their research workflow. Specifically, the entertainment functionalities, such as interactive chats, community forums, and working groups, can make users view engagement with the repository as a normal part of their daily activities. By incorporating these social features, the platform transforms from a simple repository to an interactive community hub, enhancing user experience and fostering a more engaged and collaborative user base. In this context, Sinha et al. [55] found that features like interactive chats and community forums create a sense of community among users, encouraging regular participation. This is particularly important for academic repositories, as increased engagement can lead to more frequent data sharing and collaboration. Additionally, a study by Kimmons and Veletsianos [56] highlighted that social and collaborative features in academic platforms lead to habitual use, as users begin to see the platform as an integral part of their academic workflow. This habitual use not only increases the frequency of data sharing but also enhances the overall user experience.

During the interviews, several participants proposed the integration of emerging technologies that they believed could address challenges identified in the literature or enhance the open science experience. For example, in the context of data reusability—a key aspect of the data management process—participants highlighted the potential of generative AI (GenAI). Given its rapid advancement and increasing utility in academic settings, some researchers suggested leveraging GenAI within Open REUNICE to automatically generate summaries and provide detailed insights into research publications. This functionality could streamline the understanding and dissemination of complex research, thereby promoting greater accessibility and usability of scientific outputs. In this context, a recent study by Hosseini et al. [57], highlighted the potential use of GenAI in open science. For instance, GenAI can simplify complex scientific concepts, eliminate technical jargon, and summarize findings, making research papers easier to understand for non-experts or researchers from different fields. Additionally, GenAI can help improve the identification and connection of diverse outputs, such as data and software, while enhancing their discoverability with more accurate metadata. The results of a recent survey about the use of GenAI by researchers showed that 29% from 3838 researchers are using ChatGPT for finding or summarizing research publications [58].

Furthermore, many participants highlighted the importance of incentives in open science and their potential to motivate researchers to share their research and data on the platform. Some participants emphasized the significance of including researchers' contributions to open science activities in career assessments and personal development processes. This perspective aligns with the European Commission's plans to incorporate open science activities into the research career evaluation system. It is also consistent with the viewpoints of several European universities and organizations, such as the European Open Science Cloud (EOSC), which recognize and value open science activities in research career assessments [48]. In this context, previous studies showed that researchers worried about the impact that open science practices could have on their career since in the traditional evaluation method, researchers are evaluated based on traditional journal metrics and only few incentives from a career perspective to fully commit open science [59]. Allen and Mehler [60] argued that if researchers' contributions to open science, such as preregistrations, the publication of null findings, and the inclusion of DOIs for open code or data are not valued or considered in a scientist's evaluation, then open science will struggle to establish a strong presence in the scientific community. However, different incentive systems should be implemented based on the research field, as some participants suggested, since not all research areas promote open access data. This result aligns with a previous study conducted by Toribio-Flórez et al. [61], which identified that certain open science principles, such as reproducibility, are more prevalent in specific research fields like human and social sciences. In contrast, fields such as artificial intelligence may emphasize promoting open access to data alongside incentive systems that support replication efforts. Since the attitudes of the institutions toward open science will inform the views of its staff, it is very important to align the institutional policies guiding user behavior to change the culture of sharing as highlighted by Davis et al. [49].

VI. Conclusion, Implications, and Future Directions

This study presents a newly developed open science platform Open REUNICE that harnesses the power of AI and blockchain technologies to promote and foster a culture of sharing and seamless collaboration among universities worldwide. The findings from the focus group discussions validated the hypothesis that leveraging AI and blockchain technologies enables researchers and institutions to share open science more efficiently and effectively. Participants highlighted that the platform addresses several key open science challenges frequently noted in the literature, including the automatic generation of metadata, overcoming legal barriers, and addressing social issues. For instance, the platform's ability to generate automatic metadata based on the publication text can significantly enhance the accuracy and relevance of the metadata, thereby improving content discoverability and retrieval. Additionally, by leveraging blockchain technology, the platform can help mitigate legal barriers related to intellectual property rights, fostering a safer environment for sharing research and innovative ideas. Furthermore, the platform's social features, such as instant messaging, community building, and collaborative workspaces, can promote daily engagement and facilitate a culture of open collaboration among researchers.

In addition to the proposed functionalities of the platform, the participants expressed their desire to add or modify certain features. They suggested incorporating more research databases, such as Scopus and institutional repositories, to gather publications. Additionally, the participants emphasized the importance of implementing an incentive or recognition system for open science activities that can be utilized for career assessments. Using incentives can significantly contribute to creating a robust open science culture by motivating researchers to engage more actively in open science practices.

The results of this study can be used to guide developers in refining and expanding platform features to better meet the needs of the research community, hence promoting the culture of sharing, such as implementing incentive systems. The results can also be used by institutions to develop open science policies to encourage the adoption of open science platforms based on the integration of AI and blockchain technologies to enhance research practices. Furthermore, the platform can serve as a model for international collaborations, demonstrating how technology can overcome common barriers in research sharing and intellectual property protection.

Despite the positive contribution of this study, it still has some limitations that should be acknowledged and further researched. For instance, the number of participants is limited. Additionally, all the participants were from Europe, which can affect sharing various culture perception, since researchers from different places in the world may have different perceptions towards technology based on their background and readiness. Finally, the platform collects data about researchers just from ResarchGate, which can limit the collection of data. Therefore, the future work will focus on overcoming the aforementioned limitations as well as focusing on combining AI and blockchain to overcome the limitations of each technology. For instance, the use of blockchain to overcome AI challenges, such as interpretability issues in AI models.

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