

PROBLEMS OF BIBLIOGRAPHICAL MANAGERS FOR SCIENCE AUTOMATIZATION: APPROACH TO SOLVE AND ONTOLOGICAL VIEWPOINT

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Abstract. *This paper explores the functionalities and limitations of major reference manager systems, focusing on their role in solving the author identification problem in academic research. It critically analyzes the features of popular reference managers like Zotero, EndNote, Mendeley, SciWheel, and Paperpile, assessing their capabilities in reference management and their approaches to author identification. The study reveals that while these systems offer robust reference management functionalities, including citation generation, bibliography management, and collaborative tools, they fail to integrate advanced author identification mechanisms, such as ORCID. The lack of such features highlights a significant gap in current reference management solutions, impacting the accuracy and efficiency of scholarly communication. The paper emphasizes the need for enhanced features in reference managers to address author identification challenges effectively, particularly in the context of Open Science and FAIR data management principles. This study contributes to the understanding of current limitations in reference managers. It underscores the importance of developing advanced features for accurate author attribution in the digital era of academic research. It focuses on using additional integrational data about the authors by using ORCID as the main identifier. This solution is crucial for countries with non-Latin alphabet, including Cyrillic.*

Keywords: *Open Science; FAIR Principles; Reference Managers; Author Identification; Digital Identifiers; Ontological Tools.*

1. INTRODUCTION

The automation of processes is increasingly ubiquitous and necessary in contemporary contexts. This trend encompasses the efficient collection and processing of data. Notably, Big Data mining and cognitive ontology technologies are gaining traction due to their effectiveness in facilitating decision-making processes (Stryzhak et al., 2021; Stryzhak, 2020). The significance of data in the realm of automation is manifold, playing a pivotal role in revolutionizing the practices of data scientists (De Bie et al., 2021) and enabling the automation of data analytical processes via semantic technologies (Bednar et al., 2022). In automotive production, for instance,

data-driven models are utilized for predictive maintenance and condition monitoring, with anomaly detection emerging as a significant challenge (Dierkes et al., 2021). Collectively, these studies underscore the vital role of data in propelling automation across diverse sectors.

This paradigm is equally pertinent in the scientific domain. Open Science, a movement striving for greater transparency and reproducibility in research, encompasses elements such as open access, open data, and open-source software (Méndez Fernández et al., 2019). Defined as a collaborative culture fostered by technology, it promotes the sharing of data, information, and knowledge within the scientific community and the wider public (Ramachandran et al.,

2021). This openly shared and collaboratively developed knowledge, facilitated through networks, enhances accessibility and transparency (Vicente-Saez & Martinez-Fuentes, 2018). The importance of data programs in fostering and expediting open science is also highlighted (Ramachandran et al., 2021).

The scientific community has adopted the FAIR principles — Findable, Accessible, Interoperable, and Reusable—for research data (Wilkinson et al., 2016). The FAIR framework, focusing on data openness, is integral to Open Science (Chukanova, 2022). In the Facility for Antiproton and Ion Research (FAIR) context, these principles are set to substantially advance knowledge in areas including fundamental interactions, nuclear astrophysics, and materials research (Durante et al., 2019). It is used in different specific fields as well as generally in science. For example, in geoscientific modeling, the FAIR principles are applied to ensure that research data and software are accessible and reproducible, thus enhancing collaboration and knowledge dissemination (Hut, 2022).

A specific challenge in implementing Open Science and adhering to FAIR principles is the identification of scientists and establishing links between them and their publications. Utilizing IT tools appears to be a viable solution to this challenge. Bibliographical managers serve as a database for publications. These reference managers are indispensable for researchers, offering a centralized platform for organizing, annotating, and referencing literature (Meade et al., 2023). They streamline the process of generating citations and bibliographies and can be adapted to meet specific journal requirements (Meade et al., 2023). Popular reference managers such as EndNote, Zotero, Mendeley, and Paperpile each possess unique features and limitations (Meade et al., 2023). These tools have evolved to support a variety of functions, including managing PDFs, annotating, and searching for references (Francavilla, 2018). They are beneficial for learning, teaching, and writing, thereby proving invaluable for both researchers and educators (Francavilla, 2018). They could be pivotal in automating the data related to publications and

authors. Key functions include treating authors as separate entities and merging author profiles. However, challenges arise with the variation in author metadata formats, such as different forms of last names or combinations of last names and initials. A potential solution lies in using identifiers like ORCID, although this feature is currently absent in popular reference managers. This issue is particularly relevant in non-Latin alphabet-using countries, where authors often publish in English to maximize impact. Many Slovak authors have explored and highlighted this issue. latsyshyn et al. (2021) addresses the challenges of author identification and the application of digital technologies in the scientific community, emphasizing the role of digital identifiers and global communication systems in shaping scientific identity. Roy (2020) contributes to this area by developing a framework for linking citing and cited sentences in research articles using deep learning models (Singha Roy et al., 2020). These studies collectively underscore the criticality of digital technologies, deep learning, and philosophical methodologies in resolving issues related to author identification and scholarly publication.

Therefore, **this paper aims** to explore the potential of using personal accounts of reference managers to store and process data, particularly in addressing authorization issues. To achieve this objective, the **following research questions** are investigated:

What is the current state of the most popular reference managers and their features?

What are the main challenges that reference managers face in integrating and calculating data?

What are the potential solutions to these challenges?

2. METHODOLOGY

Literature Review. A comprehensive literature review is conducted to establish a foundational understanding of the current state of reference managers and their features. We were focused on identifying relevant academic papers, technical reports, and industry publications that discuss the evolution, capabilities, and

limitations of reference managers such as EndNote, Zotero, Mendeley, and Paperpile. Special attention is given to studies that address issues of author metadata formats and the integration of digital identifiers like ORCID. Additionally, literature on the FAIR principles, Open Science, and the role of data in scientific research was analyzed to contextualize the study within the broader field of scientific data management.

Analysis of the interfaces and functions.

An empirical analysis of the interfaces and functions of the most popular reference managers is performed. This step involves a hands-on examination of each reference manager to document their features, user interface design, and functional capabilities. Key aspects such as citation generation, bibliography management, PDF management, annotation capabilities, and reference searching efficiency are evaluated. The analysis also examined how these tools manage author identification and data integration, especially in the context of non-Latin alphabet usage. The reference managers EndNote, Zotero, and Mendeley were analyzed as the most popular tools and sciwheel.

Defining the Problems. Based on the insights gained from the literature review and interface analysis, the key problems and challenges faced by reference managers is defined. This includes issues related to data integration, author identification, inconsistent metadata formats, and lack of support for digital identifiers. The impact of these problems on researchers, especially in the context of Open Science and adherence to FAIR principles are highlighted. This phase also involved identifying gaps in current functionalities that hinder efficient data management and author attribution.

Proposing Solutions. Building on the identified problems, this section proposes potential solutions to address the challenges faced by reference managers. Solutions are grounded in the findings from the literature review and analysis of current tools. This could include recommendations for the integration of digital identifiers like ORCID, enhancements in metadata handling, and improvements in user interface design for better accessibility and usability. The feasibility

of implementing these solutions, along with their potential impact on improving the efficiency and effectiveness of research data management, is discussed.

3. RESULTS AND DISCUSSION

3.1. Analysis of the interfaces and functions and Defining the Problems

Zotero, a free and open-source reference manager, offers a user-friendly platform for researchers to collect, organize, and cite diverse research materials. Compatible with Windows, macOS, Linux, and web interfaces, it supports various data types and integrates smoothly with word processors for easy citation and bibliography generation. Unique features include robust PDF management and social networking capabilities for collaborative research (see Fig. 1). Despite its comprehensive functionality, Zotero remains intuitive and accessible, catering to the needs of a diverse academic audience.

EndNote is a professional reference management software catering primarily to researchers and academics. It provides efficient tools for organizing references, creating bibliographies, and managing research documents. Compatible with Windows and macOS, EndNote integrates well with Microsoft Word, facilitating smooth citation and bibliography generation in various styles. Although it is a paid tool, its advanced features, like PDF annotation and direct import of references from databases, make it a valuable resource for serious researchers (see Fig. 2). EndNote's limitation to desktop platforms is counterbalanced by its robust data handling and organizational capabilities.

Mendeley is a versatile reference manager that combines bibliographic data organization with academic social networking. Available on Windows, macOS, and through a web interface, it offers free basic access with options for paid storage upgrades. Mendeley stands out for its PDF annotation capabilities and its ability to facilitate collaboration through shared libraries (see Fig. 3). Its integration with Microsoft Word and other word processors enables easy citation management across various styles. Mendeley's user-friendly interface, designed for both individual

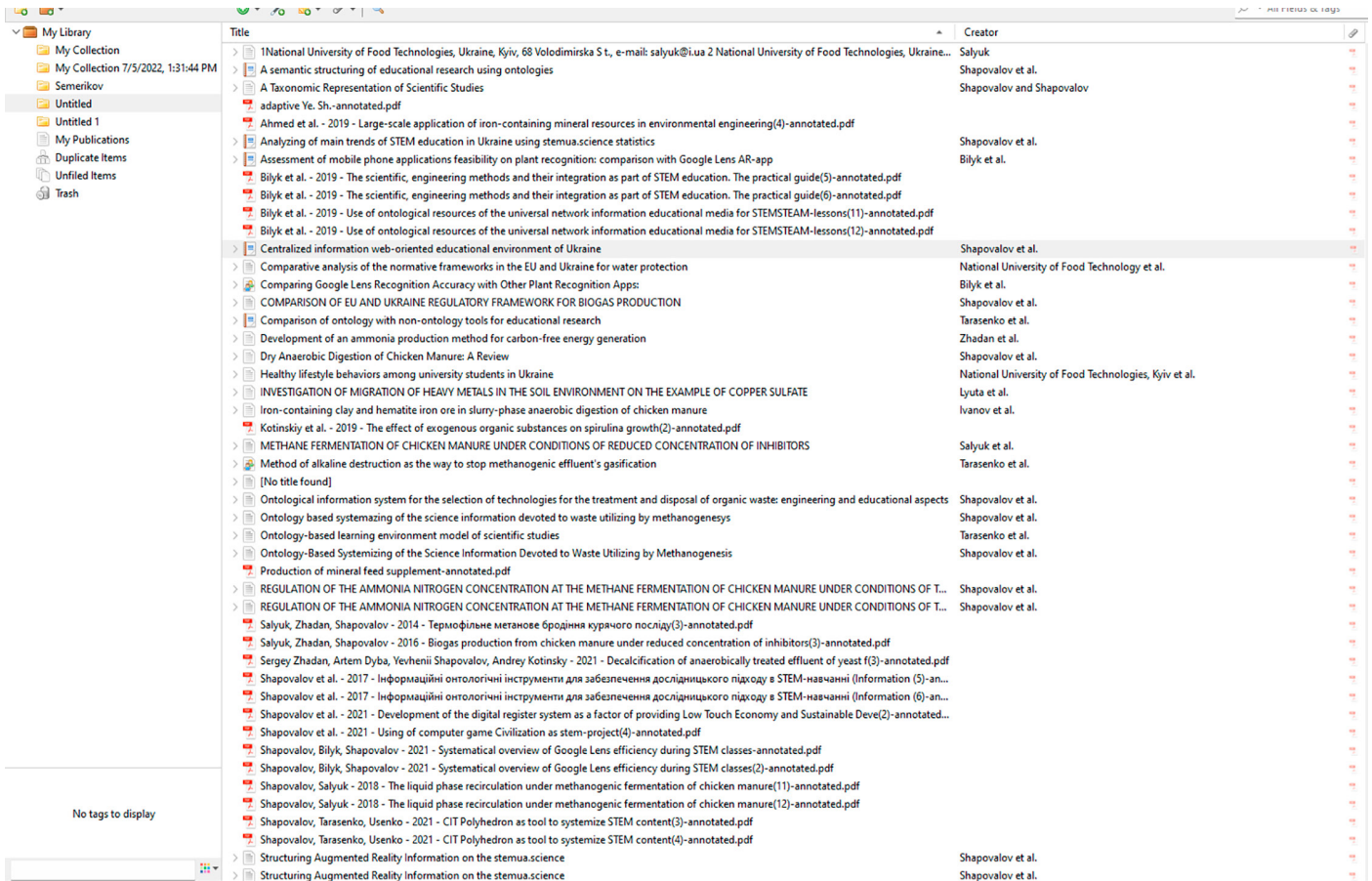


Fig. 1. General view of zotero

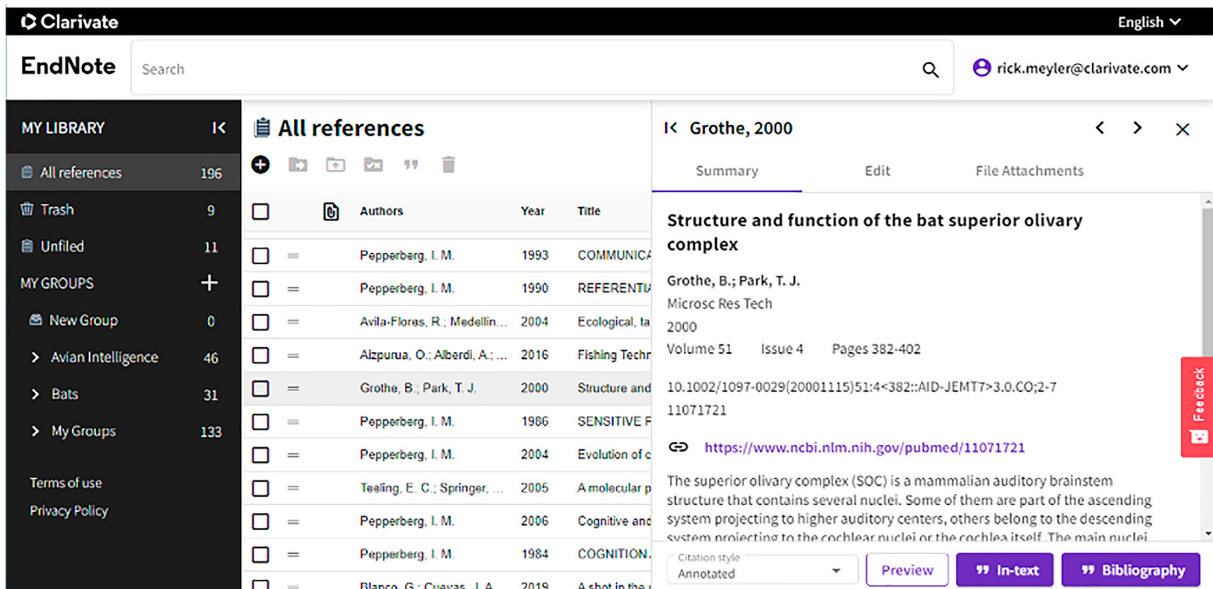


Fig. 2. Interface of endnote

researchers and collaborative groups, makes it a popular choice in the academic community.

SciWheel is a web-based reference manager offering features like instant reference saving

from the web, including Google Scholar and PubMed. Users can highlight and add notes to PDFs and web pages (see Fig. 4), access references and PDFs from any device, and utilize

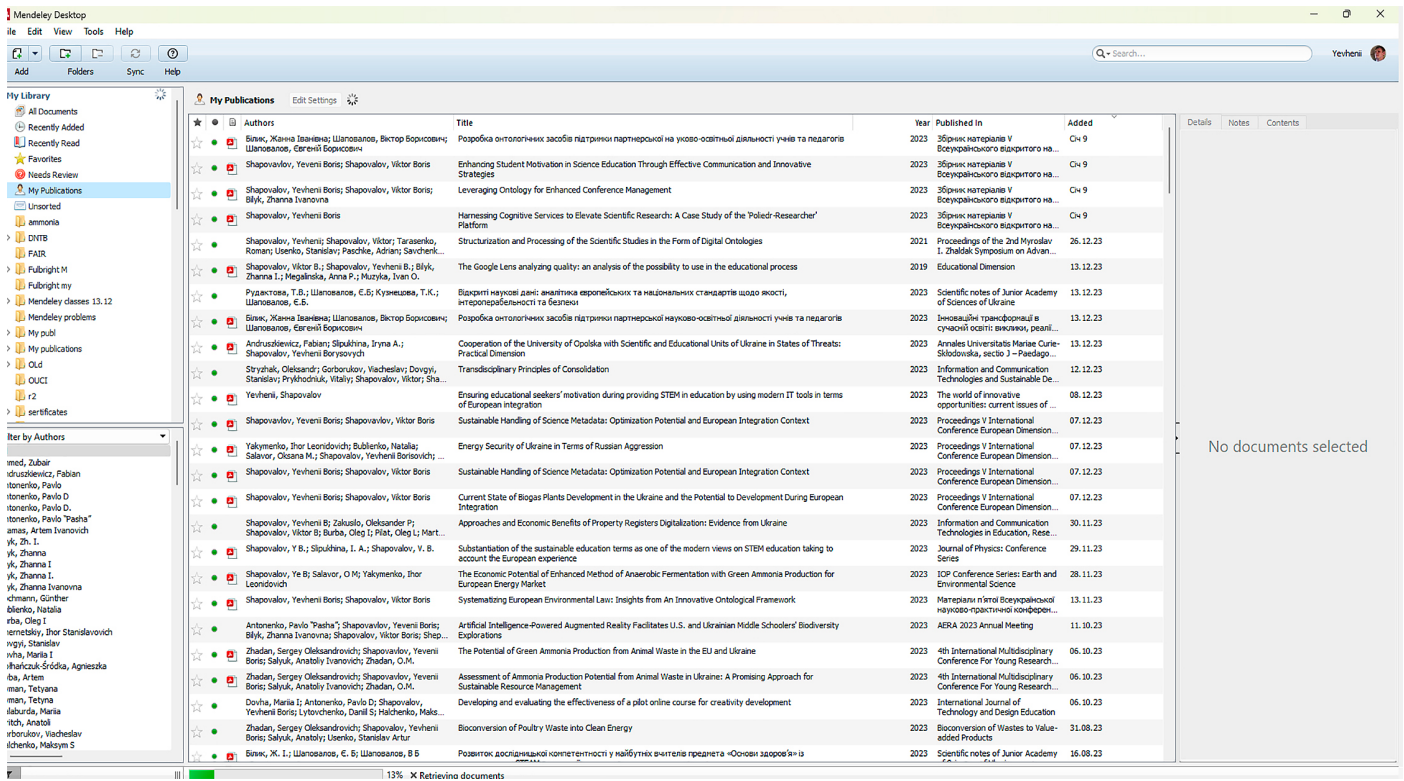


Fig. 3. Mendeley interface

collaborative tools for sharing and discussing research. SciWheel suggests relevant articles and integrates with Microsoft Word and Google Docs for citation and bibliography generation.

Paperpile is a reference manager tailored for researchers and academics. It offers efficient tools for organizing references, creating bibliographies, and managing research documents. Pa-

perpile is notable for its seamless integration with Google Docs and Google Scholar (see Fig. 5), making it particularly useful for users in the Google ecosystem. It supports a variety of citation styles and is known for its user-friendly interface. Paperpile is a subscription-based service, providing a reliable and streamlined solution for managing and citing academic sources.

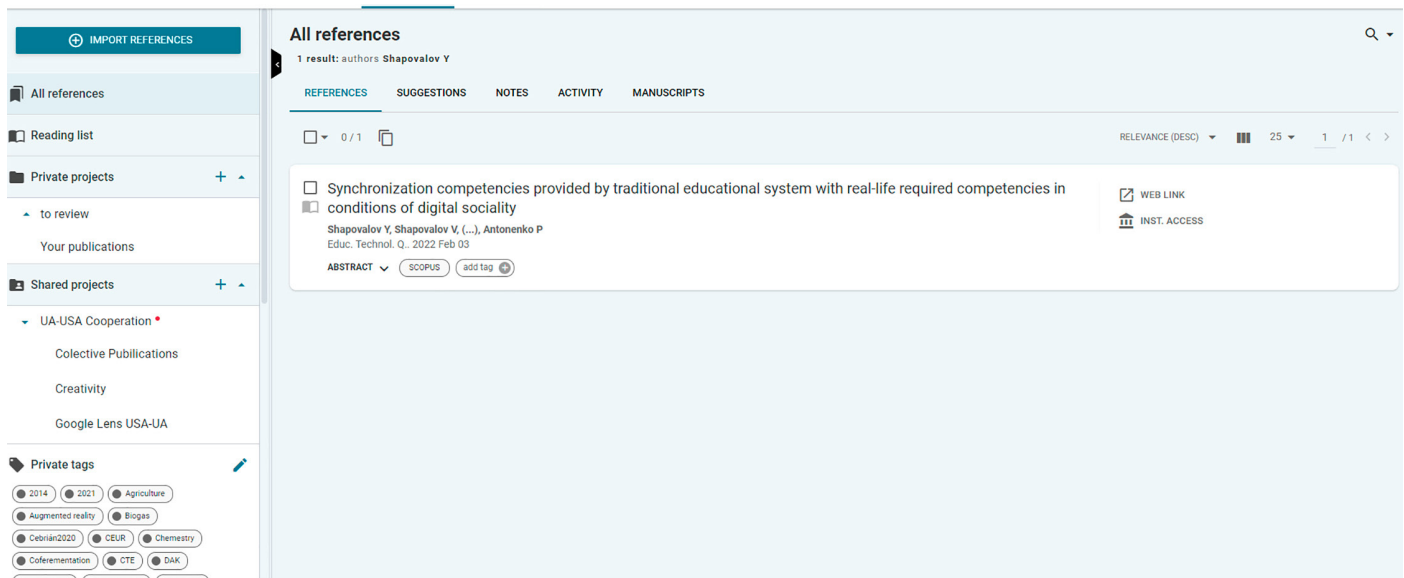


Fig. 4. Sciwheel interface

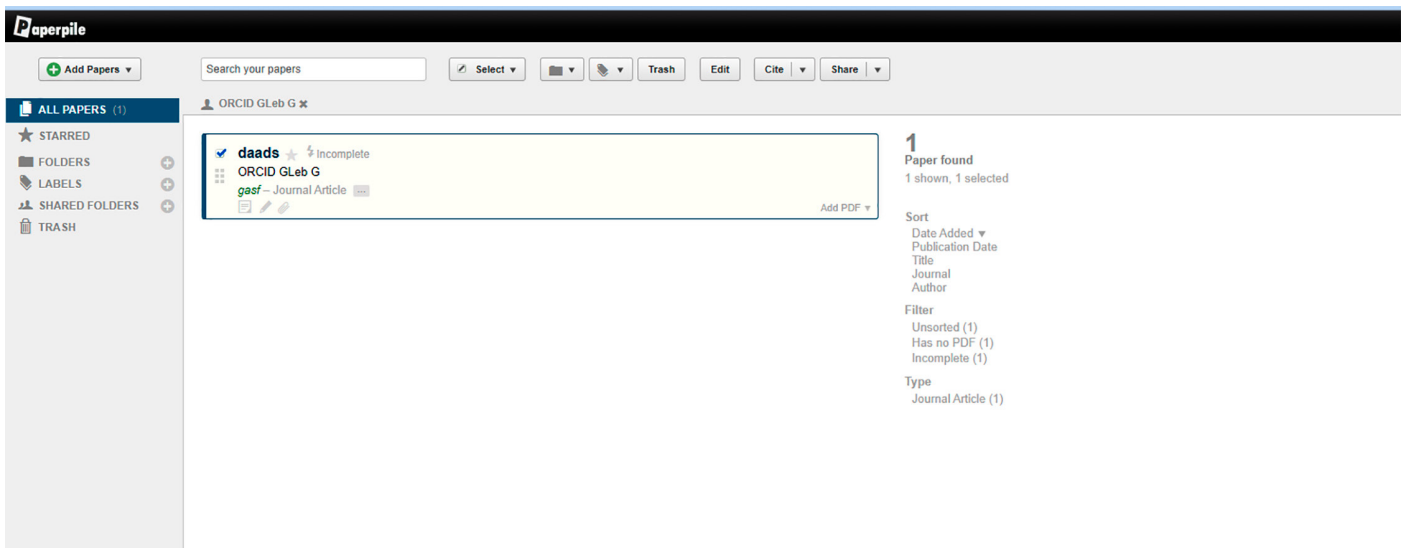


Fig. 5. Paperpile interface

In the realm of reference management software, the landscape is diverse, encompassing both paid and free models. EndNote and Paperpile emerge as paid solutions, offering robust features for a fee. Conversely, Zotero provides a no-cost alternative, albeit with the option of paid upgrades for enhanced storage capabilities. Mendeley and Sciencewheel also offer free basic plans, with advanced features and expanded storage available for a premium. The platform compatibility of these tools exhibits notable variation. Zotero stands out with its broad compatibility, supporting Windows, macOS, Linux, and web interfaces, thereby offering a versatile solution for a wide range of users. EndNote, in contrast, is confined to Windows and macOS platforms, potentially limiting its accessibility to a subset of users.

All the examined reference managers adeptly facilitate in-text citations and the generation of bibliographies across multiple citation styles, catering to diverse academic requirements. EndNote and Paperpile distinguish themselves through their seamless integration with Google Docs, a feature particularly beneficial for users embedded in the Google ecosystem. Zotero and Mendeley extend their functionality beyond mere citation management, incorporating social networking features and mobile application support, thereby enhancing user engagement and accessibility. Sciencewheel introduces a novel approach with its integration of mind maps and visual

citation analysis, offering a unique perspective in organizing and visualizing research citations.

The spectrum of collaborative features in these tools varies significantly. EndNote offers basic sharing capabilities, while Paperpile advances the paradigm with features supporting real-time collaboration, a boon for team-based research endeavors. In terms of storage, the landscape is mixed. While all software solutions provide online storage, Zotero and EndNote also facilitate local storage, affording users additional flexibility in data management and accessibility, particularly in environments with limited online connectivity. Table 1 summarizes the key features and differences among the discussed reference managers.

A critical aspect of reference management is author identification. All the discussed tools recognize both ORCID identifiers and conventional name/surname inputs for author identification. The use of ORCID is highly advocated, given its capability to uniquely identify researchers, thereby circumventing issues of ambiguity that are often inherent in name-based identification. Nonetheless, the traditional name/surname approach remains a viable fallback, ensuring inclusivity for users not registered with ORCID or in contexts where such digital identifiers are not prevalently used. This dual approach underscores the adaptability of these tools in accommodating varying user needs and practices in academic research.

Table 1

Comparison of Features in Popular Reference Managers

Feature	EndNote	Zotero	Mendeley	Paperpile	Sciencewheel
Reference Import	Supports various file types, web imports, manual entry	Supports various file types, web imports, manual entry, and browser extensions	Supports various file types, web imports, manual entry, and browser extensions	Supports various file types, web imports, manual entry, and Google Scholar integration	Supports PDF and Word imports, manual entry, and browser extensions
Citation Management	In-text citations and bibliography generation for multiple styles	In-text citations and bibliography generation for multiple styles, note-taking, syncing with online storage	In-text citations and bibliography generation for multiple styles, note-taking, social networking features, syncing with online storage	In-text citations and bibliography generation for multiple styles, Google Docs integration, sharing features	In-text citations and bibliography generation for multiple styles, mind map integration, collaborative features
Organization	Folders, tags, search, custom fields	Folders, tags, collections, search, notes, attachments	Folders, tags, notebooks, search, annotations, full-text search	Folders, labels, search, Google Drive integration	Folders, tags, search, mind map integration
Platforms	Windows, macOS	Windows, macOS, Linux, web	Windows, macOS, Linux, iOS, Android, web, desktop	Web-based, Google Chrome extension	Windows, macOS, web
Cost	Paid, with free trial	Free, with paid storage options	Free basic plan, paid plans for more storage and features	Paid subscription	Paid subscription
Storage	Local or online	Local or online	Online	Online	Online
Collaboration	Limited sharing features	Sharing features for groups and projects	Sharing features for groups and projects	Real-time collaboration features	Collaborative features for teams
Unique Features	Manuscript templates, integration with reference databases	Open-source, customizable, extensive plugin support	Social networking features, mobile apps	Google Docs integration, machine learning-based suggestions	Mind map integration, visual citation analysis
Integration with Word	Yes	Yes, via plugin	Yes, via plugin	No	No
Integration with Google Docs	No	Yes, via plugin	No	Yes, native integration	No
Author Identification (ORCID or manual)	ORCID or other IDs aren't used to identify author				

The most developed system on author identification is Zotero. However, it still doesn't use identifiers such as ORCID to identify the user. However, it just contains an additional

field — the role of the author, as shown in Figure 6. This feature is useful but still does not solve the problem with the author's identification.

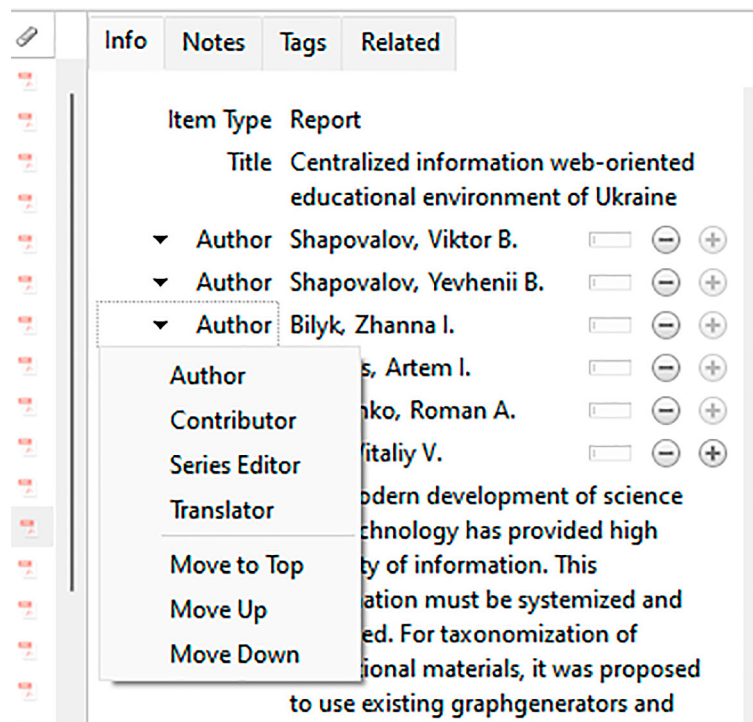


Fig. 6. Author Role Field in Zotero

Therefore, none of the proposed managers use IDs (such as ORCID) to identify scientist that will lead to problems when using them to automate scientific reporting.

3.2. Features to solve the Autor's identification problem

As Mendeley, a well-established reference management tool, exhibits several strengths and limitations in addressing the author identification challenge in academic research. The system excels in organizing scientific works, offering functionalities for importing, organizing, and searching academic papers. It is adept at automatically formatting citations and bibliographies in numerous styles and syncs libraries across devices and platforms. Mendeley's integration with popular text editors like Microsoft Word and LibreOffice simplifies citation insertion and formatting.

Notably, Mendeley provides robust group work features, allowing shared access to libraries and facilitating collaborative research. Additionally, its web importer tool enables easy importing of articles from various scientific databases and websites directly into the Mendeley library.

However, Mendeley shows a significant limitation when it comes to author identification. It lacks an integrated solution for author identification using ORCID identifiers. ORCID provides a unique identifier for researchers, which is crucial for accurately managing publication records and avoiding ambiguities in authorship. This gap in Mendeley's functionality highlights a crucial need in reference management systems — the need for advanced author identification mechanisms that ensure accuracy and efficiency in academic documentation and communication.

Other limitations of Mendeley include the absence of tools for categorizing publications by specific scientific themes or projects, the lack of functionality for academic advancement or accreditation processes, and no validation of user-added publication authenticity. Furthermore, Mendeley's limited free plan, privacy concerns due to its association with Elsevier, occasional stability issues, and the lack of a Google Docs citation module are noted as additional areas for improvement.

In summary, while Mendeley offers a comprehensive suite of features for literature management and academic collaboration, its capa-

bilities in author identification, particularly using digital identifiers like ORCID, indicate a significant area for potential enhancement. Addressing these challenges would markedly improve the scholarly communication and data management efficacy in the academic sector.

3.3. Ontological viewpoint

This issue could be used with modern cognitive and ontological tools as they proved their efficiency in solving practical tasks, including science (Dovhyi et al., 2020; Globa, Novogradskaya et al., 2020; Globa, Sulima et al., 2020; Shapovalov et al., 2022; Shapovalov & Shapovalov, 2021; Stryzhak et al., 2021; Tarasenko et al., 2020; Shapovalov et al., 2018). Previously, Polyhedron -Researcher' was developed at the National Center of Junior Academy of the Sciences of Ukraine. (Prykhodnyuk et al., 2023; Prykhodniuk et al., 2023).

The figure displays a screenshot of an interface for the Polyhedron-Researcher" system, which is described as a feature of the "Polyhedron" project by National Center of Junior Academy of Sciences of Ukraine. This system is part of the "Comprehensive Information-Analytical Platform for Forming Transdisciplinary Information-Analytical Spaces for Young Researchers".

Let's describe the main functions. The interface includes several menu items on the left, suggesting a structured approach to managing publication activities and resources. The main part of the screen provides an overview of the system's modules, which are divided into two major categories: Modules for depicting the current state of publication activity and Modules for depicting knowledge in the field of publication activity.

Under the first category, there are submodules for:

- "Quantifying Publication Activity" likely represents the quantification of researchers' publication outputs.
- "Publication Plan and its Execution" probably allows for planning and tracking publication milestones.
- "Export List of Publications", which suggests a feature for exporting bibliographic data.

- Under the second category, the following submodules are mentioned:
- "Interactive Knowledge Base" which may be a repository of indexed clusters for searching important information.
- "Journals for Publication" and "Conferences for Publication" which could be databases of potential venues for publishing research.
- "Current NAPS", which might provide information about current activities and requirements of the NAPS.
- "Scientific Results Preview" that probably offers a preview of research outcomes.
- "Current State and Decisions", which is likely to be a module for documenting and retrieving decisions and document states.

What is important is that "Quantifying Publication Activity" integrates authors through the links between different forms of the same author's name. That ensures the correct counting of the author's publication. It still does not use ORCID, however, this approach also proved its efficiency, and one of the modules of the 'POLIEDR-Researcher' counts the coefficients of correspondence to attestation criterium (where the function of merging of publication related to same author is required).

Additionally, there is a section for "Data Submission for Entering into IAC", which seems to be a data entry point for researchers to submit information to be integrated into the system. It emphasizes the importance of adhering to a specified format, suggesting automation in handling of data, possibly through Gmail.

4. CONCLUSIONS

This paper has comprehensively examined the capabilities and limitations of various reference manager systems, focusing on their role in addressing the author identification challenge in academic research. Through an extensive literature review and empirical analysis, it was determined that while tools like Zotero, EndNote, Mendeley, SciWheel, and Paperpile offer robust functionalities for reference management, their capabilities in author identification, specifically using digital identifiers like ORCID, are limited or non-existent.

This gap is significant, as accurate author identification is crucial for the integrity and efficiency of scholarly communication. The absence of advanced author identification mechanisms, such as the integration of ORCID, in these systems highlights a critical area for future development. Addressing this need is essential not only for enhancing the accuracy of academic documentation but also for supporting the principles of Open Science and FAIR data management. To solve this problem, developing specialized tools

or using ontology-based decision is possible.

The findings suggest that future enhancements in reference management systems should prioritize the incorporation of digital identifiers to resolve ambiguities in authorship and improve data management processes. This advancement would significantly contribute to streamlining academic reporting and the automation of scientific documentation, thereby bolstering the efficacy of research and scholarly communication in the digital age.

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ПРОБЛЕМИ БІБЛІОГРАФІЧНИХ МЕНЕДЖЕРІВ ДЛЯ АВТОМАТИЗАЦІЇ НАУКИ: ПІДХІД ДО ВИРІШЕННЯ ТА ОНТОЛОГІЧНИЙ ПІДХІД

Анотація. У статті досліджено функціональність та обмеження основних систем менеджменту бібліографічних посилань, з акцентом на їхню роль у вирішенні проблеми ідентифікації авторів у академічних дослідженнях. Аналізуються особливості популярних менеджерів посилань, таких як Zotero, EndNote, Mendeley, SciWheel, та Paperpile, та оцінюються їхні можливості у сфері управління посиланнями та підходи до ідентифікації авторів. Дослідження виявляє, що, незважаючи на міцну функціональність управління посиланнями, існують недоліки у інтеграції просунутих механізмів ідентифікації авторів, як-от ORCID. Відсутність таких функцій підкреслює значний пробіл у сучасних рішеннях управління посиланнями, що впливає на точність та ефективність наукового спілкування. Стаття підкреслює потребу в розширених функціях менеджерів бібліографічних посилань для ефективного вирішення проблем ідентифікації авторів, особливо в контексті Відкритої науки та принципів управління даними FAIR. Дослідження сприяє розумінню поточних обмежень менеджерів бібліографічних посилань та підкреслює важливість розвитку просунутих функцій для точної атрибуції авторів у цифрову епоху академічних досліджень. Зосереджується на використанні додаткових інтеграційних даних про авторів за допомогою ORCID як основного ідентифікатора. Таке рішення є критичним для країн з нелатинським алфавітом, включно з кирилицею.

Ключові слова: Відкрита наука; Принципи FAIR; Менеджери посилань; Ідентифікація автора; Цифрові ідентифікатори; Онтологічні інструменти.

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