

DIGITAL PUBLISHING

Typical cases and implications of enhanced publishing on chemistry publishing platforms

Wenjie Dong*

National Science Library, Chinese Academy of Sciences, Beijing 100190, China

ABSTRACT

In the digital age, enhanced publishing has become an increasingly important innovation in academic communication. This study investigates the enhanced publishing strategies adopted by three major chemistry publishing platforms: The American Chemical Society (ACS), the Royal Society of Chemistry (RSC), and Wiley. Through case analysis, this paper highlights how these platforms utilize technologies such as three-dimensional (3D) molecular visualization, semantic enrichment, interactive databases, and multimedia embedding to support open science and improve research dissemination. The findings provide valuable references for enhancing the publishing capabilities of Chinese academic journals in the field of chemistry.

Key words: enhanced publishing, semantic enrichment, chemistry publishing platforms

INTRODUCTION

With the continuous development of digital technology and the rise of open science, enhanced publishing has become increasingly important in scientific communication. Compared to traditional publishing models, enhanced publishing enriches the forms of research output and promotes deeper changes in scholarly exchange and knowledge dissemination through multidimensional information integration, improved data accessibility, and interactive user experiences. The FAIR principles—Findability, Accessibility, Interoperability, and Reusability have provided a foundational framework for data-intensive scientific publishing.^[1] In China, scholars have also emphasized the strategic value of enhanced publishing in bridging knowledge production and dissemination across platforms and communities.^[2,3]

Enhanced publishing has emerged as a response to the limitations of static academic articles, particularly in data-intensive fields such as chemistry. It is generally defined as the integration of structured data, multimedia, and external resources into the publishing process to

improve content representation and research transparency.^[4,5] Multimedia elements and interactive visualization technologies significantly enhance clarity, interactivity, and reusability of research content.^[6] Prior studies have summarized three core directions of enhancement including media, semantics, and data,^[7,4] each corresponding to a different dimension of content structuring and accessibility.^[8]

Recent studies further suggest that interactive and semantic features, alongside open-access mandates and infrastructure developments, are collectively reshaping the scholarly publishing landscape. Lee *et al.* analyzed over eight million figures from PubMed to reveal that articles with greater scientific impact tend to have richer visual content, underscoring the importance of visual communication in scientific journals.^[9] McNutt *et al.* put forward a series of suggestions on open data sharing from multiple perspectives including funders, publishers, scientific research communities, data repositories, and scientific societies, which cover supporting specialized repositories, standardizing data management and citation, promoting cultural changes, and providing technical support, *etc.*^[10] Bechhofer *et al.* pointed out that

***Corresponding Author:**

Wenjie Dong, National Science Library, Chinese Academy of Sciences, No. 33 North Fourth Ring West Road, Beijing 100190, China. E-mail: dongwj@mail.las.ac.cn; <https://orcid.org/0000-0002-7885-2532>

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while linked data is essential, effective semantic publishing requires integrated platforms that combine rich metadata, ontology services, and user-friendly interfaces to ensure machine readability.^[11] Nuzzolese *et al.* presented research on automatic semantic annotation of scholarly documents, focusing on citations and their automatic classification using the CiTalO framework.^[12] Peroni and Shotton introduced OpenCitations infrastructure providing open citation identifiers and linked RDF-based APIs to support semantic interlinking and transparency in scholarly publishing.^[13]

In practice, enhanced publishing also relies on the development of effective data visualization approaches. These serve as a critical bridge between data and cognition but face challenges such as the complexity of representing high-dimensional data. Techniques such as immersive virtual reality and embodied navigation are increasingly being explored to optimize the presentation and comprehension of complex scientific content. At the same time, many current visualization tools still depend heavily on tidy, well-structured data, creating barriers in the preparation process. This highlights the need for enhanced publishing to address not only the visual layer but also the ease of data processing to support knowledge dissemination.^[14–16] Semantic publishing has also evolved from early experimental models to practical implementations: for example, the International Union of Crystallography (IUCr) toolkit supports core interactive figures in crystallographic publications. Furthermore, advances in automated experimentation have enabled high-fidelity simulations and self-driving laboratories, which depend on standardized protocols and machine-readable data formats. In this context, chemical knowledge graphs play a vital role in supporting the transition from data to actionable knowledge.^[17–19]

Internationally renowned publishing institutions such as the American Chemical Society (ACS), the Royal Society of Chemistry (RSC), and Wiley have each launched their own initiatives in enhanced publishing, demonstrating diverse approaches to multimedia integration, semantic structuring, and intelligent publishing workflows. This article takes these three publishing platforms as the main objects of study, examining representative cases of their enhanced publishing practices and analyzing their respective strategies and technological focuses. The aim is to provide insights and references for the ongoing development of enhanced publishing models in China's chemistry journals and scientific publishing infrastructure.

THE ENHANCED PUBLISHING STRATEGY OF THE ACS

3D visualization of molecular structures

Since April 2023, ACS has expanded its collaboration with the Cambridge Crystallographic Data Centre

(CCDC) to introduce 3D structure visualization features in journals such as *Inorganic Chemistry*, *The Journal of Organic Chemistry*, *Organic Letters*, and *Organometallics*.^[20] For qualifying research papers where crystallographic information files (CIF) are stored in the CCDC, their article pages directly display interactive 3D molecular structures. Readers can view details or download the original data through the supporting information section. This initiative builds upon the experience gained from an earlier implementation in *Crystal Growth & Design* in February 2022, reflecting ACS's deep understanding of the importance of intuitive 3D data presentation in chemical research (Figure 1).^[21] The feature aims to enhance research transparency and data sharing efficiency, requiring authors to upload data *via* CCDC's CIF submission service and follow specific procedures for file generation, alert feedback, and revision synchronization. In the future, ACS plans to extend this functionality to more journals, further optimizing the structure visualization experience.

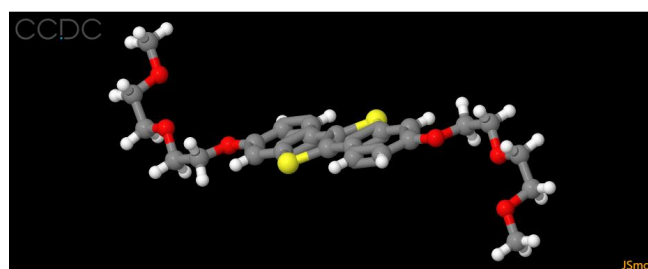


Figure 1. 3D structure *via* CCDC's CIF. 3D, three-dimensional; CCDC, Cambridge Crystallographic Data Centre; CIF, crystallographic information files.^[21]

This technological innovation synergizes organically with ACS's data strategy. The reliability of the 3D visualization feature depends on the continuous supply from associated databases, a mechanism ensured through strict data submission policies.

ACS's strategy emphasizes embedding links in articles pointing to CCDC records, thereby achieving data transparency and reproducibility. Authors must submit crystallographic data to the CCDC before manuscript submission, ensuring data consistency and high quality. Furthermore, through linkage with the Inorganic Crystal Structure Database (ICSD), ACS has built a broader, more interactive data management system, further promoting open science practices.

Interactive features

Through deep integration with the Chemical Abstracts Service (CAS) SciFinder database, ACS has implemented enhanced services enabling resource linking and interactivity. When readers browse the references of papers on the ACS platform, the system leverages CAS's

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Nanoparticle Superlattice Engineering with DNA

NEXT >

MacFarlane, Robert J.; Lee, Byeongdu; Jones, Matthew R.; Harris, Nadine; Schatz, George C.; Mirkin, Chad A.

Science (Washington, DC, United States) (2011), 334 (6053), 204-208 CODEN: SCIEAS; ISSN:0036-8075. (American Association for the Advancement of Science)

A current limitation in nanoparticle superlattice engineering is that the identities of the particles being assembled often determine the structures that can be synthesized. Therefore, specific crystallographic symmetries or lattice parameters can only be achieved using specific nanoparticles as building blocks (and vice versa). The authors present six design rules that can be used to deliberately prepare nine distinct colloidal crystal structures, with control over lattice parameters on the 25- to 150-nm length scale. These design rules outline a strategy to independently adjust each of the relevant crystallographic parameters, including particle size (5 to 60 nm), periodicity, and interparticle distance. As such, this work represents an advance in synthesizing tailorable macroscale architectures comprising nanoscale materials in a predictable fashion.

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10. Macfarlane, R. J.; Lee, B.; Jones, M. R.; Harris, N.; Schatz, G. C.; Mirkin, C. A. Nanoparticle Superlattice Engineering with DNA. *Science* 2011, 334 (6053), 204–208, DOI: 10.1126/science.1210493 10 Nanoparticle Superlattice Engineering with DNA MacFarlane, Robert J.; Lee, Byeongdu; Jones, Matthew R.; Harris, Nadine; Schatz, George C.; Mirkin, Chad A. *Science* (Washington, DC, United States) (2011), 334 (6053), 204-208 CODEN: SCIEAS; ISSN:0036-8075. (American Association for the Advancement of Science) A current limitation in nanoparticle superlattice engineering is that the identities of the particles being assembled often determine the structures that can be synthesized. Therefore, specific crystallographic symmetries or lattice

SEE ALL REFERENCES

Figure 2. The reference quickView of ACS. ACS, American Chemical Society.^[22]

authoritative data resources to automatically identify and highlight entries belonging to ACS publications. Clicking on these entries activates the "Reference QuickView" feature, directly displaying the target literature's abstract, authors, journal information, and DOI link within the original article page (Figure 2).^[22] This functionality retrieves metadata and abstract content, ensuring information accuracy and timeliness. Simultaneously, users can click the "SciFinder" button for a one-click jump to the CAS SciFinder platform to further search for related compounds, reaction pathways, or extended literature, forming a workflow from a single paper to an abstract quick view to in-depth search. The "PRINT" function supports the quick generation of standardized bibliographic information for archiving or sharing. This service not only relies on CAS's vast chemical data indexing capabilities (covering global journals, patents, and substance information) but is also deeply coupled with the ACS publishing platform *via* loading technology, transforming traditional references into operable knowledge nodes. It guarantees the authority of academic data while significantly improving the information retrieval efficiency for researchers, reflecting the transformation of academic publishing from static content to open, tool-based services.

Multimodal content embedding

ACS's "web-enhanced objects (WEO)" is a technical solution that enhances the online presentation of papers through multimedia attachments, aiming to use elements like videos, interactive 3D models, and dynamic data to overcome the limitations of print media and help readers understand research details more intuitively.^[23] ACS requires WEOs to be submitted concurrently with the

main manuscript, and all files must adhere to strict technical specifications. For example, file size must not exceed 5 MB, and formats must be compatible with mainstream browsers and devices. Graphics files (such as PDF and TIFF) should be within 640 × 480 pixels. 3D models (such as CIF and PDB formats for crystal structures) must support online interaction, such as rotation and zooming. Video content (MPEG, QuickTime, *etc.*) needs to meet frame dimensions of 480 × 360 pixels and a playback rate of 12-15 frames per second. Spectral data must be saved in JCAMP-DX format to allow dynamic parameter adjustments. For textual supplementary materials (such as experimental details or data tables), ACS accepts common formats like TXT, DOC, and XLS. Through WEOs, authors can intuitively demonstrate complex mechanisms (*e.g.*, videos of chemical reaction processes). This strategy enhances the paper's comprehensibility and ensures data reusability through standardized formats (such as CIF and JCAMP-DX), reflecting the transition from "static display" to "interactive service" in academic publishing within the context of open science.

Multimedia sharing

ACS's WeChat sharing function and open access (OA) full-text display represent a further extension of the enhanced publishing concept. As shown in Figure 3, by scanning a quick response (QR) code *via* WeChat,^[24] readers can quickly convert a paper link into a mobile-friendly format, leveraging the dissemination advantages of social media, especially in the WeChat-dominated Chinese market, allowing academic content to permeate wider social networks. This strategy enhances the accessibility of academic content. For OA journals, scanning the code to directly access the full text aligns with

enhanced publishing's support for open science. From a publishing ecosystem perspective, the combination of WeChat sharing and OA also reflects the flexible application of ACS's regionalization strategy. By customizing different sharing tools for user habits in different regions (*e.g.*, WeChat in China and Twitter in Europe/America), it embodies the "user-centric" philosophy of enhanced publishing. Through WeChat and OA functionalities, ACS extends the boundaries of enhanced publishing from the content itself to the dissemination channels and access scenarios, making research outcomes not only richer but also more accessible. This full chain enhancement, from production to distribution, is a key path for the transformation of academic publishing in the digital age.



Figure 3. WeChat QR code for ACS's article shares. QR, quick response; ACS, American Chemical Society.^[24]

THE ENHANCED PUBLISHING STRATEGY OF THE RSC

A leader in semantic publishing

The RSC has achieved a leap from traditional publishing to structured semantic content through chemical entity recognition, data interconnection, and user interaction tools. Integration with RSC's comprehensive chemical database, ChemSpider, highlights a strategic advantage, positioning RSC as a leader in semantic publishing. The technology systematically extracts chemical entities from journal literature, using natural language processing to automatically identify key information like compound names and reaction conditions. These entities are accurately matched with unique identifiers in the ChemSpider database *via* InChIKey. This approach not only resolves the issue of synonyms for chemical substances (same substance, different names) but also provides a data foundation for subsequent semantic annotation. To structure literature content, RSC developed an independent chemical ontology library, defining conceptual models and semantic relationships within the chemistry domain, and establishing logical connections using Web Ontology Language (OWL).^[25]

Building on data integration, RSC embeds semantic functionalities into various publication formats. In collaboration with the University of Manchester, they developed Utopia Documents, extending semantic capabilities to the PDF format by parsing and identifying chemical entities and their associated information, breaking the static limitations of PDFs. Additionally, for mobile adaptation, RSC optimizes mobile views, prioritizing text loading and displaying compound diagrams only when needed, ensuring smooth access. RSC deeply integrates semantic publishing into its entire workflow, becoming a model for the intelligent transformation of academic publishing through systematic technological innovation and standardized practices.

Text and data mining (TDM) empowerment

RSC empowers chemical research by promoting TDM.^[26] Its core strategy involves transforming journal content into machine-readable, enhanced data resources to meet the demands of research analysis and knowledge integration in the digital era. RSC's TDM is becoming critical infrastructure, integrating dispersed knowledge nodes into contextually linked knowledge networks, enabling researchers to quickly find relevant cutting-edge research and data support (Figure 4). Researchers can extract key parameters, reaction pathways, or material property data from RSC's structured literature to build predictive models or infer cross-disciplinary innovation paths, achieving efficient "evidence-driven" R & D across various fields, including agrochemicals and food chemistry, batteries and electrochemistry, and chemical analysis.

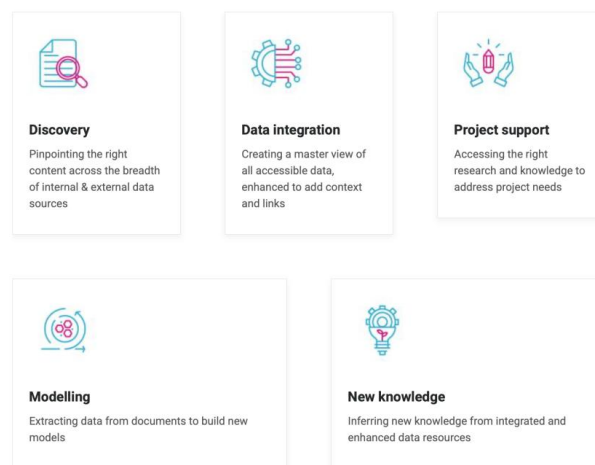


Figure 4. Advantages of RSC's TDM.^[26] RSC, Royal Society of Chemistry; TDM, text and data mining.

RSC is committed to achieving the goal of "publishing as machine-analyzable", making structured formats like extensible markup language (XML) the "digital

infrastructure" for research information. This allows newly published research findings to be immediately accessible to TDM tools, laying the foundation for knowledge integration across institutions and disciplines. This TDM-centric enhanced publishing strategy allows data-driven innovative thinking to permeate the entire chain from basic research to industrial application, becoming a vital engine for accelerating development in chemical sciences.

WILEY'S ENHANCED PUBLISHING STRATEGY

Multimedia enhancement

Through its subsidiary Atypon, Wiley introduced interactive figures technology in the *International Journal of Quantum Chemistry* (*IJQC*), enabling dynamic, interactive chart presentation. Using this technology, computational chemistry articles published in *IJQC* can include interactive 3D molecular visualization features.^[27] Readers can directly rotate, zoom, and interact with chemical structures (Figure 5). Some articles feature fully interactive, zoomable charts, enhancing data visualization capabilities. By integrating researchers' source code and experimental notes, this significantly improves research transparency and reproducibility.

Research enablement solutions

Wiley's exploration in enhanced publishing extends beyond traditional academic content dissemination. Through technological innovation, it deeply integrates research tools with the publishing ecosystem, constructing an enhanced system spanning the entire chain from data generation to results publication. Wiley offers scientific solutions (Wiley Science Solutions) *via* its KnowItAll software and accompanying databases, focusing on spectral analysis and chemical data management. It integrates powerful software tools with the world's largest collection of spectral databases, aiming to help laboratories improve analytical quality, reduce errors, and enhance work efficiency.

Regarding core products and technological advantages, Wiley possesses the world's largest spectral collection, encompassing over 5 million spectra covering mass spectrometry, infrared, Raman, nuclear magnetic resonance, and ultraviolet-visible. Among these, the Wiley Registry of Mass Spectral Data is the largest commercial mass spectral library, supporting untargeted spectral searches and ensuring the breadth and reliability of analytical results. The KnowItAll spectral analysis software can integrate and process spectral data, enabling cross-modal analysis (Figure 6).^[28] New versions introduce several features: For liquid chromatography-mass spectrometry (LC-MS) analysis, the new liquid chromatography (LC) Expert tool can convert raw

chromatograms into component identification results with one click, alongside a new dedicated LC-MS library containing over 2.7 million spectra. Furthermore, its ChemWindow module can draw 2D chemical structures and has advanced stereochemistry recognition capabilities.^[29] ReportIt generates professional reports including structures; SymApps is used for 3D display, modeling, and computation; 3DViewIt visualizes 3D structures; BrowseIt provides training resources and product news links; SearchIt searches databases; MineIt/Database Building manages databases. The software also includes a clipart library, calculation tools, and a mass spectrometry (MS) fragmentation tool. Its search functionality is powerful, allowing searches by various categories and modes across extensive databases. Additionally, the software is equipped with a formula calculator, and documentation lists data for some compounds and information on controlled substances.

Through AI-driven automation (*e.g.*, machine learning-assisted peak recognition) and multimodal data fusion (*e.g.*, linking spectral and structural data), Wiley's Science Solutions is progressively transforming from a data provider to an intelligent solutions partner, continuing to lead in the field of research tools.

CONCLUSION

Enhanced publishing drives platform strategy upgrade

The case analysis of ACS, RSC, and Wiley shows that enhanced publishing is not merely a supplement to the presentation format of traditional static papers but has become a crucial engine driving the overall transformation of publishing platforms. ACS ensures data standardization and transparency through 3D molecular structure visualization and rigorous data upload processes. RSC leverages semantic publishing and text data mining technologies for precise identification and linking of chemical entities, providing strong support for structuring literature content. Wiley integrates interactive multimedia with intelligent research tools, forming a full-chain service from data generation to results publication. These strategies indicate that publishing platforms are accelerating their transformation from traditional information display to open, interactive, and intelligent services, centered around data integration, content interactivity, and smart algorithms.

Multimodal interaction promotes intuitive communication of research outcomes

All three institutions emphasize using 3D visualization, interactive charts, and multimedia content to build intuitive presentation platforms. ACS achieves timely display and information sharing of crystallographic data

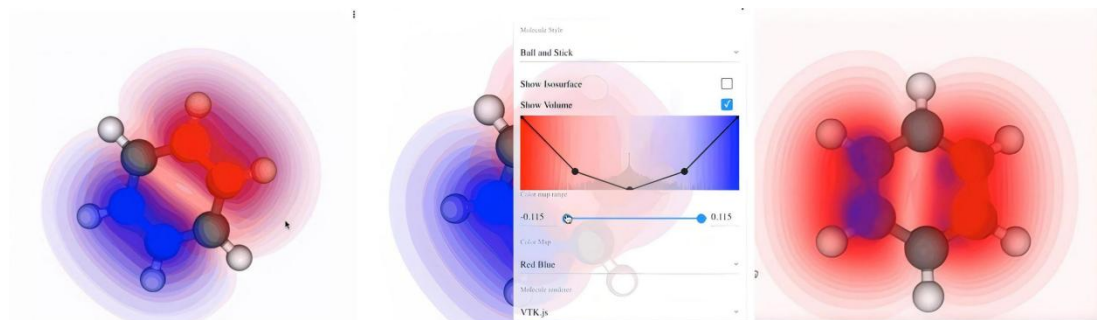


Figure 5. Interactive figures in the *International Journal of Quantum Chemistry*.^[27]

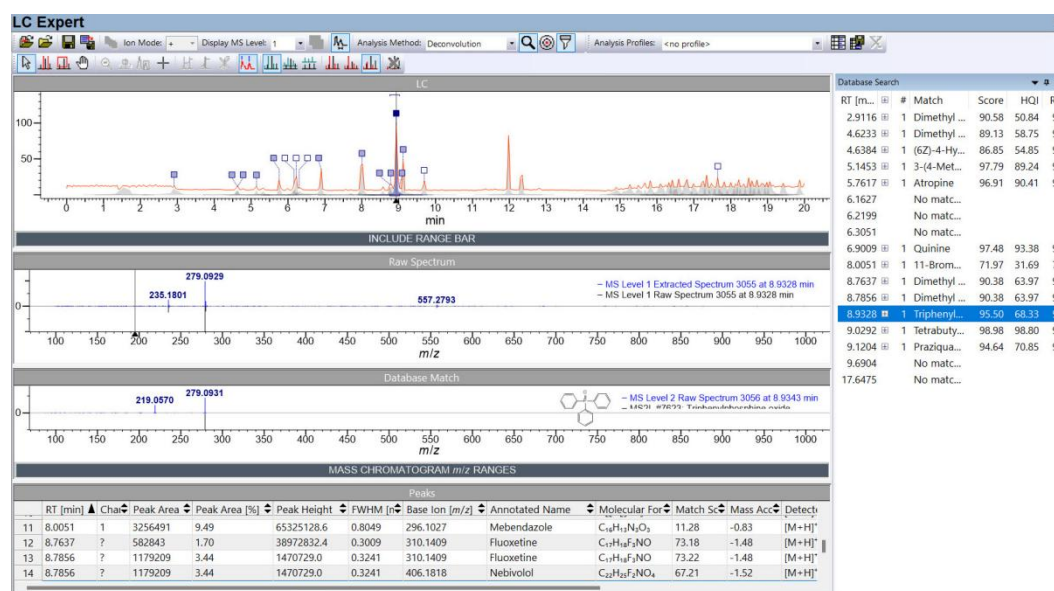


Figure 6. The KnowItAll spectral analysis software.

through linkage with authoritative databases like CCDC in its interactive 3D displays. Wiley's interactive figures technology allows readers to perform data operations like rotation and zooming directly within the platform, enhancing information interactivity. RSC effectively improves the communication efficiency of research outcomes by organically combining structured data with visualization methods through semantic annotation and mobile optimization. Multimodal presentation not only improves the reading experience of research papers but also facilitates research replication and secondary analysis.

Data linkage and semantization build an intelligent publishing ecosystem

Improving data accessibility is a core demand in the current development of enhanced publishing. ACS forms a closed-loop management from data entry to online interaction by requiring authors to submit CIF files and linking with multiple databases (such as ICSD and SciFinder). RSC achieves machine readability of

literature data and enables TDM functions using ChemSpider and its self-built chemical ontology, laying the foundation for cross-domain data integration. Wiley transforms traditional chemical data into open, intelligent research resources relying on its vast spectral databases and AI-driven data processing tools. This model, using data as a link and integrating semantic annotation and XMLization, not only helps break down information silos but also promotes the transformation of research data into intelligent service platforms.

Implications

Recent global analyses, such as the 2023 STM OA Progress Report, emphasize that the next phase of scholarly communication will be shaped by openness, cross-sector collaboration, responsible AI deployment, and advanced data infrastructures.^[30] Based on the discussion above, the development of enhanced publishing models should revolve around the following core directions (Figure 7). (1) Openness and interconnection: strengthen data uploading, certification, and

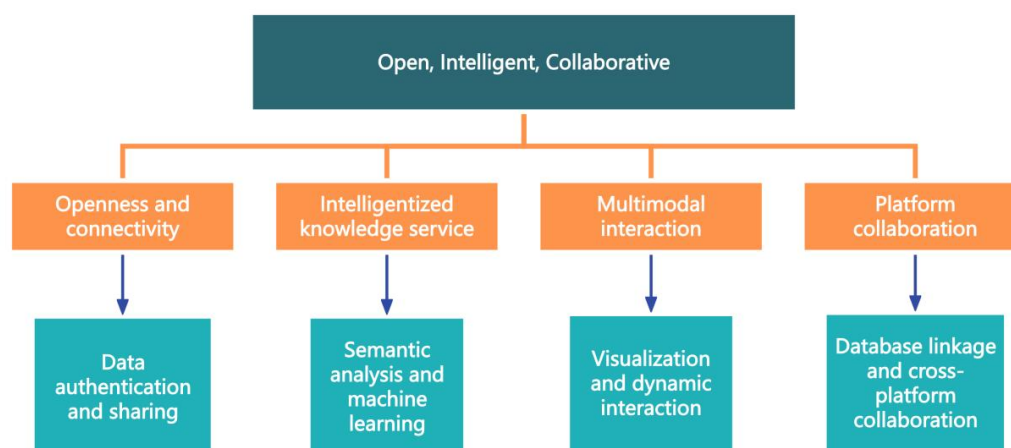


Figure 7. The future of enhanced publishing.

sharing to achieve seamless integration from research outcomes to open data resources. (2) Intelligent services: utilize technologies like semantic analysis and machine learning to enable deep mining and automated processing of literature content, improving researchers' efficiency in information retrieval and utilization. (3) Multimodal interaction: actively promote 3D visualization, dynamic charts, and multimedia presentation methods to make research content intuitively visual, building more efficient communication bridges for interdisciplinary collaboration and results sharing. (4) Platform collaboration: leverage database linkage and cross-platform cooperation to build a "paper-data-service" trinity enhanced publishing ecosystem, shifting from single information release to full-process research services.

For Chinese scientific journals, enhanced publishing should not be viewed merely as a presentation technique but as a significant opportunity for platform upgrades and reshaping the academic service system. Currently, Chinese scientific journals are still in the exploratory stage regarding technical paths, content standards, and platform collaboration for enhanced publishing. It is urgent to define core enhancement directions (such as 3D models, data integration, and semantic linking) based on disciplinary characteristics. Simultaneously, attention must be paid to integrating with research workflows and aligning with practical usage scenarios, ensuring that enhanced publishing functions genuinely serve the research production process, thereby enhancing the journal's academic influence and publishing value.

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Dong W contributed solely to the article.

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Informed consent

Not applicable.

Conflict of interest

The author declares no competing interest.

Use of large language models, AI and machine learning tools

None declared.

Data availability statement

No additional data.

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