IJDC | *Conference Paper*

An Exploration of the Functionality and Usability of Open Research Platforms to Support Open Science

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Abstract

This paper examines the user experience and functionality of four open research platforms—Zenodo, Figshare, OSF, and Authorea—to assess their utility in disseminating research outputs that are varied in form as well as academic discipline, and in facilitating collaboration on larger projects by multi-institutional groups. The researchers analysed the platforms' community features, record creation processes (including metadata fields), search functionality, and analytics capabilities.

Submitted 9 February 2024 ~ *Accepted* 22 February 2024

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This paper was presented at the International Digital Curation Conference IDCC24, 19-21 February 2024

The *International Journal of Digital Curation* is an international journal committed to scholarly excellence and dedicated to the advancement of digital curation across a wide range of sectors. The IJDC is published by the University of Edinburgh on behalf of the Digital Curation Centre. ISSN: 1746-8256. URL: http://www.ijdc.net/

Introduction

re3data,[1] a global registry for research data repositories created in 2013, lists over 3,000 repositories, many of which focus on scientific data sets (Pampel et al., 2023). However, research products include grey literature, dissertations, project reports, conference presentations, and other publications not disseminated through publishers. Additionally, while institutional repositories enable individual scholars to share work, these are not always useful for multi-institutional groups and projects with diverse research products. Researchers who are deciding where and how to share their scholarly products may (and often do) contend with multiple factors, including their intended audience, the diversity of their research products, disciplinary norms and customs, and funding body requirements.

Over the last decade, several open research platforms have enabled individuals and groups alike to share and access diverse research products outside traditional publication channels. However, understanding the full capabilities of these platforms is necessary for gauging their usefulness in terms of sharing research products with broader audiences.

This study systematically examines four prominent open research platforms: Zenodo,[2] Figshare,[3] Open Science Framework (OSF),[4] and Authorea.[5] This research assesses these platforms' user experience and ability to provide meaningful dissemination and access to scholarly content for both individual users and groups, which can aid scholars in deciding which platforms(s) meet their needs. The platforms were examined via a set of guiding questions based on previous literature. The remainder of this paper provides a review of previous research, this study's research methods, selected findings, and a discussion and conclusion.

Related Literature

Related research has often focused on use cases of one platform, general single-platform analyses, and comparative platform studies of one discipline or type of research product.

Researchers have examined the utility of most of these platforms for data sets spanning a variety of disciplines. Zenodo has proven useful to researchers working with herbarium (Dillen et al., 2019), archaeological (Hiebel et al., 2021), and cultural heritage data (Bucciero et al., 2023). Takhtoukh (2019) discussed the process of using Figshare for humanities research data, and Tackett et al. (2019) examined OSF's usefulness for clinical psychology research.

Additionally, researchers have explored the implementation processes at the institutional level. Gonzales et al.'s (2021) study concerned an institutional implementation of InvenioRDM, the software underlying Zenodo, while Sinhababu, Gakhar, and Chakravarty (2022) explored the process of setting up an institutional repository via Zenodo itself as an SaaS. Scherer and Valen (2019) discussed the implementation process of Figshare for Institutions at Carnegie Mellon University. Other studies in this vein focus on specific features of Figshare and OSF (Potterbusch & Lotrecchiano, 2018; Riegelman, 2018; Wani & Bhat, 2022).

A number of studies focus on one specific aspect or feature of a single platform. Some salient examples include studies of analytics (Deneen et al., 2022; Peters et al., 2017), metadata and quality control (Pănescu & Manta, 2017; Sicilia, García-Barriocanal, & Sánchez-Alonso, 2017), and OSF's "preregistration" feature (Chen et al., 2023; Sijtsma et al., 2021). Other studies that directly compare platforms have typically been discipline- or product-specific. Forero, Curiosos,

[1] re3data: https://www.re3data.org/
[2] Zenodo: https://zenodo.org/
[3] Figshare: https://figshare.com/
[4] OSF: https://osf.io/
[5] Authorea: https://www.authorea.com/

and Patrinos (2021) focused on biotechnology data, and Murphy, Bar-Sinai, and Martone (2021) on biomedical data; Krishnamurthy, Deshpande, and Sajana's (2021) analysis centred on data sets, and Chaleplioglou and Kouloris (2023) studied multiple platforms for preprints.

Platform user-experience studies provided valuable guidance for this analysis. For example, Gonzales et al. (2021) examined the interactions that require human intervention with a software's interface, termed "microinteractions", to assess how easily researchers could use their InvenioRDM-powered institutional repository.

Several comparative platform studies provided useful background and guiding questions. Krishnamurthy, Deshpande, and Sajana's (2021) study broadly analysed Zenodo, Figshare, Harvard Dataverse, and Mendeley Data. Forero, Curioso, and Patrinos (2021) examined several features of OSF, Zenodo, Figshare, Dryad, and four biotechnology-specific platforms. Murphy, Bar-Sinai, and Martone (2021) compared eight platforms for biomedical data, some generalist and some domain-specific; their list of analysis questions proved immensely useful for this study.

While these studies have been informative, more research needs to be conducted. For example, the biomedical researchers served by the platforms Murphy, Bar-Sinai, and Martone (2021) discussed may have different needs than researchers in other fields in terms of sharing their research outputs. This study aims to comprehensively compare the user experience and functionality of four platforms, in order to help researchers in any discipline find the most useful place to share and disseminate their research products.

Methods

During the spring of 2022, four open research platforms (Zenodo, FigShare, Open Science Framework (OSF), and Authorea) were examined for this study, specifically in regards to platform functionality and usability. The selection criteria for the study were open research platforms that could host a variety of research products and included ways for both individuals and groups of scholars to share their research products.

An additional ten platforms were reviewed and discarded from the study, often due to focusing on only one type of research product. Some of these platforms were reviewed because they were mentioned in the literature. The list of platforms that were initially reviewed but discarded is as follows, presented with the reason the researchers discarded them:

- arXiv[6]; there appeared to be no way to create a community or project page for wider, cross-institutional research endeavours.
- Mendeley Data[7]; aimed mainly at hosting data sets rather than a wider range of research products.
- Harvard Dataverse[8]; aimed mainly at hosting data sets rather than a wider range of research products.
- Dryad[9]; aimed mainly at hosting data sets. Several types of research products *can* be uploaded here, but they must be associated with a specific scholarly publication.
- Qeios[10]; no apparent way to create a community or project page, and the site seemed mostly geared towards online peer-review.
- DataLad[11]; open-source software for dataset management aimed at researchers.

[6] arXiv: https://arxiv.org/
[7] Mendeley Data: https://data.mendeley.com/
[8] Harvard Dataverse: https://data.harvard.edu/dataverse
[9] Dryad: https://datadryad.org/
[10] Qeios: https://www.qeios.com/

- ICPSR[12]; focused on hosting data sets and aimed more at institutions.
- EPrints[13]; commercial product for institutional repositories.
- Digital Commons[14]; commercial product for institutional repositories.
- OpenAIRE[15]; not one single platform, but rather a suite of tools for research data management and sharing, including Zenodo

The platforms ultimately chosen for examination were Zenodo, Figshare, OSF, and Authorea. These platforms were selected because they are domain-agnostic, web-based, and open to any type of research product.

The researchers assembled a comprehensive list of guiding questions to assess each platform's functionality and user-friendliness. These guiding questions were based in part on the previous research described in the literature review.

Specifically, guiding Questions 1 through 9 were either inspired by or directly taken from three sources: 1) Forero, Curioso, and Patrinos, 2021; 2) Krishnamurthy, Deshpande, and Sajana, 2021; and 3) Murphy, Bar-Sinai, and Martone, 2021. Additionally, the researchers devised Questions 10 through 15 to create a fuller analysis of each platform. The 15 guiding questions are listed below.

1. What document or data types are allowed?
2. What is the maximum upload size?
3. Can the platform integrate with GitHub?
4. Does the platform have an API?
5. Does the platform support relations between objects?
6. Does the platform provide or support persistent identifiers such as DOIs?
7. Does the platform allow users to completely delete records, or does it keep the metadata for archival purposes?
8. Does the platform account for versioning?
9. Can the platform integrate with ORCID?
10. Can people share record pages easily via social media?
11. Can people share community or collection pages easily via social media?
12. What levels of administrative control, access, and/or embargoing are available?
13. Does the platform support Creative Commons licences?
14. Can users save drafts of research products? Can they share those drafts privately?
15. Is there a specific metadata field for funding information in a record?

[11] DataLad: https://www.datalad.org/
[12] ICPSR: https://www.icpsr.umich.edu/sites/icpsr/home
[13] EPrints: https://www.eprints.org/uk/
[14] Digital Commons: https://www.elsevier.com/products/digital-commons
[15] OpenAIRE: https://www.openaire.eu/

Finding answers to many of these questions, particularly regarding user experience, required the researchers to create an account and interact with each platform. Taking cues from Gonzales et al.'s (2021) institutional repository user testing script tasks, the researchers engaged in tasks that included 1) examining project-based and multi-contributor functionalities, 2) creating records, including uploading files and adding metadata, and 3) performing site-wide searches and examining available search filters. The researchers also examined each platform's available analytics on the record and community levels. Lastly, the researchers examined ancillary materials on each platform's website, including FAQ pages, community sites, and platform-related social media, to address additional questions.

Findings

In this section, answers to the guiding questions enumerated in the methodology section are presented first, followed by more detailed findings concerning community features, record creation with a focus on metadata fields, search functionality, and available analytics for each platform.

Answers to Guiding Questions

Table 1. A summary of the findings for each guiding question. "Unknown" indicates that the information was not readily apparent on the platform, even after extensive scrutiny.

Question	Zenodo	Figshare	OSF	Authorea
What document or data types are allowed?	Any	Any	Unknown	Any file format, but categorises everything as a preprint
What is the maximum upload size?	50 GB per data set	20 GB, but not clear whether this is "per file" or "per user"	Unknown	No more than 25.1 MB for videos; no other file size limit apparent
Can the platform integrate with GitHub?	Yes	Yes	Yes	Yes
Does the platform have an API?	Yes	Yes	Yes	Unknown
Does the platform support relations between objects?	Yes. Individual records can include multiple documents and can be linked through hyperlinks.	Yes. Individual records can include multiple documents. Collections and Projects can also be used to create item relations.	Yes. Projects establish relations between objects. The wiki feature within Projects enables longer-form explanations of relations.	Somewhat. In order to create relations between documents, a user would have to create hyperlinks within the text of both documents.
Does the platform provide or support persistent identifiers such as DOIs?	Yes. A user can provide an already-assigned DOI, or Zenodo will assign a DOI via	Yes. However, there is no apparent option to include already-assigned DOIs.	Yes. A user can create a DOI for Projects. However, users cannot provide already	Yes. A user can request a DOI through the site, which Authorea assigns via

	DataCite.		assigned DOIs.	Crossref.
Does the platform allow users to completely delete records, or does it keep the metadata for archival purposes?	Keeps archival metadata	Keeps archival metadata	Keeps archival metadata	Unknown

Table 1. *Continued from previous page*

Question	Zenodo	Figshare	OSF	Authorea
Does the platform account for versioning?	Yes, via DOIs.	Yes, via DOIs.	Yes, via checksums on individual files.	Yes, via Git.
Can the platform integrate with ORCID?	Yes	Yes	Yes	Yes
Can people share record pages easily via social media?	Yes, via sharing buttons.	Yes, via sharing buttons.	Yes, via sharing buttons.	Yes, via URL (no sharing buttons).
Can people share community or collection pages easily via social media?	Yes, but only via the Community hyperlink.	Yes, via sharing buttons.	Yes, via sharing buttons.	Yes, via URLs (no sharing buttons).
What levels of administrative control, access, and/or embargoing are available?	Open, embargoed, restricted, and closed access options available. Users can request access to restricted records.	Open, embargoed, and link-only access are options.	Administrator, read/write, and read-only permissions	Edit access to papers for those added as collaborators, view-only access for those provided with a private link
Does the platform support Creative Commons licences?	Yes. All Creative Commons licences are options, although other licence types can be used.	Yes, but only two CC licences are an option (CC0 and CC-BY 4.0). There are limited non-CC options available.	Yes, but only two CC licences are an option (CC0 and CC-BY 4.0). However, a user can upload a license.txt file to the project if needed.	Yes, but only two CC licences are an option (CC0 and CC-BY 4.0). There are limited non-CC options available.
Can users save drafts of research products? Can they share those drafts privately?	Yes and no, respectively	Yes and yes, respectively	No and yes, in a way. OSF Projects can be made private initially, and view-only links can be generated.	Yes and yes; users can generate view-only links for drafts.
Is there a specific metadata field for	Yes	Yes	No	No

funding information in a record?				

Community Features

Community features were reviewed to determine if the platform supported multi-user and multi-product collection and dissemination. For example, could the platform support a project with multiple scholars disseminating discrete research products as part of one collection? In essence, could multiple scholars create a unified collection of research products? It was found that Zenodo and Figshare are similarly structured. Zenodo Communities and Figshare Collections are groupings of existing scholarly products on the site, curated by one "administrative user". Administrative users can add their own research products or those uploaded by other non-administrative users to their Community or Collection. However, while users can submit research products they upload for possible inclusion in an existing Community on both Zenodo and Authorea, Figshare does not seem to have a similar submission mechanism. Authorea Communities also have concrete lists of members, and Editors can choose whether to open membership to general Authorea users.

With OSF, projects are the default type of record. OSF projects are centralised compilations of files pertaining to a research project. While projects can have collaboration among multiple users, individual files in a project do not have their own records and metadata and, therefore, do not exist independently, as on Zenodo and Figshare. Figshare also has a Project feature similar to OSF's, though it is not the only means of organising groups of files or collaborating with others.

Metadata and Record Creation Functionality

Record creation was reviewed for all platforms to assess their user experience for common tasks such as uploading files or adding metadata. Zenodo, Figshare, and OSF allow users to easily upload files by dragging and dropping. Authorea's default record creation mode is a browser-based text editor, so uploading existing files requires slightly more work.

Metadata is one area in which these platforms differ significantly, both in terms of what fields are available and which are required. These differences are summarised in Table 2 below:

Table 2. A comparison of required and optional metadata fields on each examined platform.

Field	Zenodo	Figshare	OSF	Authorea
Title	Required	Required	Required	Required
Author(s)	Required	Required	Default; user is automatically a contributor, and other contributors can be added	Required
Item type	Required (called "upload type")	Required	Defaults to project	Unavailable
Description	Required	Required	Optional	Unavailable; not separate from the document itself
DOI	Default; automatically assigned if field is left blank, but users can also enter an	Optional; user can reserve a DOI when creating a record, but it's not	Optional; user can create a DOI for a public project after its creation, but it's	Default; automatically assigned

	existing DOI	mandatory	not mandatory	
Publication date	Required, but defaults to current date	Defaults to current date, but additional date (e.g., first publication) can be added	Default; timestamp of creation is recorded	Defaults to current date

Table 2. (continued) Required and optional metadata fields on each examined platform.

Field	Zenodo	Figshare	OSF	Authorea
Licence	Required	Required	Optional	Required
Access type	Required	Defaults to open, but users can apply embargoes or create private view-only links for drafts	Optional; users can create projects as private and later make them public	Defaults to public, but users can create private links for drafts
Subjects, tags, or keywords	Optional; available fields are "keywords" and "subjects" (for controlled vocabularies)	Required; fields are "categories" and "keywords"	Not available as a separate metadata field, though the search engine picks up on and suggests keywords	Optional (called "tags")
Community	Optional	Optional	Unavailable (projects essentially *are* the communities)	Optional
Funding	Optional	Optional	Not available as a separate metadata field, but could be included in the item's description	Not available as a separate metadata field, but could be included in the item's texts
Language	Optional	Unavailable	Unavailable	Unavailable

Zenodo is the only platform to offer a range of optional metadata fields for specific types of publications, including conference papers, book chapters, or reports. Figshare's record creation features proportionately more required fields than Zenodo's (for instance, it requires users to assign both a "Category" and "Keywords" to their uploads, whereas keywords are optional for Zenodo), but it contains fewer fields overall. OSF and Authorea have even fewer metadata fields. The only two fields required to create an OSF project are a title and a geographic storage location for files, and other fields can be populated later. These metadata fields apply to the project as a whole; individual files within a project do not have the same richness of metadata applied to them. Authorea requires some basic information, including a title, at least one author, and a licence, but tagging research products by subject is optional.

Searching and Finding

Searching and finding research products was also reviewed to see how easily users (both on and outside a given platform) could discover research products published on a platform. As with metadata fields, search filters and sorting methods varied among these platforms. Zenodo and Figshare have similar filters, including type, subject matter, and access. However, Figshare's "Category" filter is case-sensitive, meaning research products tagged with, for example, "Music

Performance" and "Music performance" are grouped separately. OSF has only two filters, item type (e.g., files, projects, registrations) and suggested keywords, and there are no sorting methods. Authorea only allows searching by predefined tags; there is no free-text searching, and the only sorting method is reverse date order.

As for discoverability outside these platforms, research products' metadata can be gathered from the platforms and shared by at least two methods: OAI–PMH,[16] a general metadata harvesting protocol, and Schema.org,[17] which is how Google indexes information. Zenodo and Figshare both share record metadata through OAI–PMH and Schema.org. No evidence was found that either OSF or Authorea supports either method of metadata harvesting.

Analytics

Measuring the impact of research is often required for reports to funding bodies and researchers' home institutions, but it can also be useful more generally for gauging just how open (i.e., findable, accessible, etc.) one's research is. As such, the researchers examined the analytics features available on each platform. Table 3 provides a comparison.

Table 3. Available analytics and statistics from each platform, for individual records unless indicated otherwise.

Zenodo	Figshare	OSF (project-level analytics)	Authorea
Views (both total and unique)	Views (presumably total, no distinction provided)	Unique visits	Record-level: views
Downloads (both total and unique)	Downloads (presumably total, no distinction provided)	Time of day	Record-level: peer reviews, which appear essentially as comments under an article
Data volume (total amount of data downloaded from a record page)	Citations	Referrers	
Citations	Altmetrics[18]	Popular pages	

Zenodo and OSF are the only two platforms that specifically track unique record- or project-level visits (respectively), and Zenodo is the only platform at all to differentiate between total and unique downloads. Figshare does not differentiate between total and unique downloads, but it is notable in that it allows users to embed records in other websites (e.g., in YouTube video descriptions or on personal websites), and it tracks analytics from those embedded items as well. Additionally, Zenodo and Figshare both track citations for records, though Zenodo's citation feature is in beta. The researchers found no evidence that OSF tracks downloads or citations; however, one unique feature of OSF's analytics is that it tracks referral sources. Authorea, meanwhile, only tracks total record views and number of peer reviews.

Some of these platforms also provide community-level analytics, although the level of detail in the data collected varies widely. OSF is the outlier in this sense, because its default unit of research is a project, and it collects statistics on that level. Zenodo does not offer community-level statistics in aggregate; a user could simply sum statistics for individual records within a community, though this would become impractical at scale. Figshare tracks community-level metrics, and

[16] OAI–PMH: https://www.openarchives.org/pmh/
[17] Schema.org: https://schema.org/
[18] Altmetric: https://www.altmetric.com/

communities also have their own DOIs. Authorea communities' pages include the number of community members and the number of published articles.

Discussion

All of the platforms discussed in this paper have their advantages and limitations, although the balance between advantages and limitations differs among platforms.

Zenodo provides a wide array of metadata fields for uploaders to utilise, several of which also serve as search facets for site users. Some of these search facets, furthermore, are not utilised on any other platform examined for this study, for example, language (although language is an optional metadata field on Zenodo, and, ergo, its utility as a filter may be limited). However, Zenodo also does not make it as easy as some other platforms (namely Figshare) to create links between different research products. Figshare allows uploaders to link to a peer-reviewed scholarly publication associated with their research product, even if that publication is not hosted on Figshare; the only way to create a similar link in Zenodo would be to embed or simply paste that link in the research product's description field.

A larger issue with Zenodo, however, is how it handles contributor names. On the upload screen, the metadata field for contributor names is one single free-text box where uploaders should list all contributors' names. The field's instructions state that uploaders should list names in a particular order, that is, "[surname], [given name and any subsequent names]", but the field itself does not include any mechanism for enforcing this order. This lack of structure has two major consequences, one of which is obvious upon performing any search, or examining Zenodo's homepage: not all uploaders follow these instructions. The other consequence has to do with Zenodo's citation generator, available on the record page for any given uploaded research product. Citations in (for example) MLA format should largely be correct if name data is entered according to the field's guidelines, because author names are largely written in that same format of "[surname], [given name and any subsequent names]". However, the fact that surnames and given names are all ultimately in the same metadata field means that any citation formats that use initials—perhaps most prominently APA, are generated incorrectly on Zenodo because the generator does not have a separate given name from which to derive an initial, or initials if applicable. While the citations themselves can be edited once they are copied and pasted into a text document, the lack of structure surrounding name metadata is still a sizeable issue that could have consequences for research-product findability beyond what is explored here.

As mentioned in the findings section above, Figshare bears many structural similarities to Zenodo. Figshare does, however, have some inconvenient aspects of its user interface that are worth examining. The file upload process on Figshare presents a couple of potential challenges. The upload screen itself is not a separate webpage, but rather a pop-up screen accessible by an "Upload" link/button on the top bar. Once a user clicks on it, the upload screen overlays whichever webpage the user is currently on. The upload screen has an X in the top right corner that could easily be mistaken for a "close window" button due to its placement. In fact, clicking on that little "X" *deletes* any file that a user may have uploaded while on this screen. The word "delete" does appear, in small font, next to that "X" when a user hovers their mouse pointer over it. However, it appeared very quickly *after* the first researcher clicked on the "X", under the impression she was about to close out of the upload screen. Figshare does seem to be aware that this particular user interface decision is a stumbling block, because immediately after one deletes a file, the text "delete" is replaced by "restore".

Another inconvenience users can face with Figshare has to do with the layout of its record page, specifically its media viewer. Upon navigating to a record's Figshare page, a user is presented with a media/file viewer that spans all of the window's horizontal space and perhaps 50 to 60% of its vertical space (depending on screen size and aspect ratio), in which the file (or one of the files) in any given record is presented. While this more horizontal layout could be very well-suited for landscape-oriented images or videos, it tends to render any portrait-oriented item—for example, many PDF documents—more difficult to read. The media viewer has a full-screen mode, but if a

user wants to read a PDF document in this viewer without using that mode, then they must resign themselves to a lot of scrolling.

Figshare's search functionality is helpful in many ways, featuring several useful facets by which searchers can filter their results. However, one drawback of Figshare's data structures comes into play with searching: subject tags, called "categories" on the platform, are case-sensitive. "Music performance" and "Music Performance" are two separate tags. This is not made clear anywhere in the record creation interface for the uploaders' benefit. Neither is it explicitly spelled out in the category filter, where available categories are listed not alphabetically, but by the number of records associated with a category, in descending order. It would be extremely easy for searchers to simply not realize that multiple variations of a given tag are available here—and as such, it is correspondingly harder for searchers to find all the relevant scholarly material that a platform could offer regarding any given subject.

OSF has several notable features that none of the other platforms have, although its lack of search filters or file-level metadata means its content is perhaps less easily accessible than content on other platforms. Ultimately, many of its advantages and disadvantages alike come from the fact that the platform is centred around *projects*, rather than individual *research products*. The "project" format is expansive in scope, and it is easy for users to upload their research products along with contextual documents for those products, for example, a dataset and a readme.txt explaining the data. However, OSF has fewer metadata fields for its projects overall than either Zenodo or Figshare does for their records, and many of those fields are optional; therefore, it is easier for uploaders to forget to fill them in, or choose not to fill them in. Even a DOI, which other platforms like Zenodo use for version tracking, is optional for an OSF project. Additionally, these project-level metadata fields do not seem to apply to the individual files uploaded within projects. Projects record edits made to individual files in an activity feed, and individual files have authentication via checksums, which goes a long way towards promoting trust and transparency within projects. However, that does very little to make individual files discoverable in OSF's search; one of the very few search facets available allows users to filter by item type, including project or file, but the lack of file-level metadata, compounded with a lack of sorting methods or other filtering options, makes the existence of that search facet feel a little pointless.

As Authorea is the newest platform of the four analysed in this paper, no prior literature has examined it yet. Its user interface is certainly attractive, with its default method of creating content being a text editor reminiscent of platforms like Medium. Users can upload existing files rather than reconstituting documents in this text editor, though this feature is less obvious. However, in comparison to the other platforms, Authorea's search functionality is not as robust, and the platform's largest issue for potential users is how its search functionality operates. As mentioned in the findings section above, searching on Authorea is by pre-defined tags only—tags that previous uploaders have already used for their content. There is no free-text search available. Users searching for content are, therefore, dependent on uploaders tagging their content in a sufficiently thorough and appropriate manner. This issue is compounded, furthermore, by the fact that (as noted in Table 2 above) tags are an optional metadata field on Authorea. As such, if an uploader chooses not to tag a research product that they upload to Authorea, or forgets to tag it, their content is essentially rendered impossible to find on the platform, and correspondingly it cannot be accessed and reused by other users of the platform.

It should be noted that although these platforms vary rather widely in terms of how easily scholars can make their various scholarly products available, and how easily users can find those works, they do all have concrete features supporting trust and transparency such that users can be more confident in these scholarly products in and of themselves. Interestingly, the platforms all handle versioning in slightly different ways. Zenodo updates a record's DOI any time an uploader makes a sufficiently substantial change to that record (and they outline what constitutes a sufficiently substantial change on their website); all prior versions of a record are still accessible through their own DOIs on the record's page, though by default any DOI resolves to the record's most recent version. Figshare does not require DOIs for uploads, so it correspondingly does not use DOIs to account for versioning, but any record with multiple versions will have a dropdown menu on its record page through which users can peruse all prior versions. OSF includes checksums on each individual file in a project, and a project's main page also has a "Recent Activity" feed that shows who made edits to what file, and when (although it is unclear whether

prior versions of files are still accessible). Authorea's version control mechanisms are also a bit unclear, though the website states that it accounts for versioning specifically because it is built on Git.

While these platforms each have varied advantages and drawbacks, ultimately the point of this study is not to unilaterally prescribe one platform for all possible use cases. Researchers themselves, as individuals and/or groups, will be best equipped to decide which platforms' affordances and limitations are most compatible with their scholarly goals.

Future Directions and Conclusion

Platforms such as the four discussed in this paper are important for facilitating open science and open research, because they provide researchers with ways to upload and share their works widely. However, what each user needs from a dissemination platform will be different depending on the nature of their research, their discipline(s), their funders' requirements, and other such factors. This study aimed to present a granular comparison of four open research platforms, examining their advantages and limitations alike, in order to aid researchers who are searching for the platform best suited for their particular works.

One limitation of this study is that while the data was gathered fairly recently (spring/summer 2022), the platforms analysed may have undergone updates since the initial analysis; in fact, since this study was conducted, Zenodo has updated its name fields and thereby fixed the problems identified earlier in the discussion section. However, even if/when updates have occurred, this study provides a comprehensive comparison of four well-known platforms that should largely still be informative and useful to researchers.

Further directions for this research could take a variety of forms, including more in-depth examinations of the roles played by ORCIDs, DOIs, licensing, or metadata harvesting on these platforms. Additionally, user studies in the same vein as Gonzales et al.'s (2021) methodology could be fruitful; Gonzales et al. actively solicited feedback from users on the platform they were testing, which was not in scope for this study but could be a valuable approach for future efforts. Subsequent work could also analyse how exactly these repositories enact or support the FAIR principles (Wilkinson et al., 2016)—regarding datasets specifically, but also applying the principles more widely, to other research products.

Overall, this paper examines very specific and important platform functions through the guiding questions and test-user explorations. From a practical perspective, this research provides answers to many questions platform users will consider during their platform decision-making process. Furthermore, this research provides platform designers with a review of the current functionality of the platforms, which can be helpful for future platform development for both current and future platforms.

Acknowledgements

This project is supported by the National Science Foundation Office of Advanced Cyberinfrastructure in the Directorate for Computer Information Science under Grant #21275488. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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