The Reciprocal Relationship Between Open Science and Open Education

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ALMS Framework | FAIR Framework | Open Education | Open Science | Reusability

Learning scientists are discovering that one of the best ways to promote effective learning is essentially to get out of the learners' way. Much like an open door allows for unobstructed freedom into and out of an area, openness in education has the goal of enabling more learning by removing obstructions, often due to copyright, expenses, and other restrictions on content, practices, and people. Similarly to open education, open science is often hampered by obstructions that impede quality research. When it is difficult to access data, analysis, or documentation, scientific progress slows. While more vulnerable, it is essential to develop trust in research through open science practices. Other scholars, practitioners, teachers, and the general public need to be able to trust research findings, and that trust is largely derived by how transparent and open researchers are in showing their process and methods. While open education and open science have evolved independently, the core ethics and goals are similar for both movements. In fact, open education and open science can be more successful and impactful together. As indicated in the 5Cs Framework (West & Wiley, 2024), open science practices are an open custom that can be part of open education and a powerful pedagogy for teachers to employ by training

students as citizen scientists. In this chapter, we will briefly discuss the shared foundations and values supporting both open education and open science. We will then provide specific guidance in how new open scientists can utilize the available resources to adopt open science practices in their own research.

Learning Objectives

By the end of the chapter, you will be able to:

1. Define open education and open science.
2. Describe the benefits of openness in education and research.
3. Apply the FAIR framework to making research studies open.
4. Apply the four steps to successfully archive the research purpose, methods, analysis, and final products of a research study.

Shared Foundations for Open Education and Open Science

While representing different traditions and sprouting from different historical backgrounds, both the open education and open science movements have similar shared goals and address similar challenges. In this section we will briefly discuss these shared foundations.

Increased Access

Perhaps the strongest goal of both open education and open science is to improve access to information. Textbook and material cost is often one of the largest prohibitive costs for learners. For example, the textbook publishing industry recorded $4.3 billion in revenue in 2024 after textbook costs rose over 1,000% in nearly 40 years (Hansen, 2026). At the same time student loan debt peaked at $1.7 trillion (Hansen, 2025). These costs limit participation in schooling or increase negative academic outcomes (Kremer et al., 2013; Rondeau, et al., 2025) and makes meeting sustainable development goals (SDG) difficult for developing countries as educational transformation for the least developed countries could require up to 47% of the gross domestic product (UNCTAD, n.d.).

Similarly, global research is hampered by the lack of access to research for all scholars around the world. For example, Bauhoff and Oroxom in 2015 estimated that a single policy report with 45 references would cost $630, which can be prohibitive for many scholars and countries and limits the ability of many international scholars to participate and publish

scientific research and use research to craft policy. Over time, this has led many research funders in Europe in 2018 to require research teams to make their research publicly available (Brainard, 2021). However, the fees can be too expensive for many research teams, costing up to €9500 for some publishers (Brainard, 2021). Thus, open education and open science share similar goals of breaking down paywall barriers to publicly funded and created knowledge and content, making increased access a key reason for openness.

Restored Trust

Scientific research is facing a credibility crisis, and educational research is not immune. This crisis has resulted in a lack of trust in the products of scientific research due to many questionable practices, including:

1. Widespread replication failures across disciplines, raising questions about whether research findings that cannot be replicated can be meaningful at all (Yong, 2018).
2. Publication bias towards positive results, sometimes due to funding pressures, giving a false sense of what is “real” in the world. In a way, research suffers from the same altered and false sense of reality that social media creates for individuals by only showing positive and filtered views of the world (Buchman & Rosenbaum, 2024.
3. Similarly, questionable research practices such as p-hacking, (calculating endless statistical tests with various variables until you achieve a p value less than .05); HARKing (hypothesizing after the research data is known); selective reporting (publishing only part of the research data/findings, usually the positive ones), and even faked data. These practices lead to a growing lack of trust in the research that is published (Hollenbeck & Wright, 2017).

These and other scientific problems are described in more depth in another chapter of this book (West & Tawfik, 2026). The solution to the lack of trust created by scientific malpractice is to increase transparency in the research process. This includes publishing open access to the methods, instruments, data, and analysis used to generate scientific findings. In addition, preregistration of hypotheses and research methods show the intention of the researchers ahead of their studies, which can prevent p-hacking and results manipulation. Finally, open peer review models can increase feedback, strengthening the eventual research conclusions. Similarly, open practices can help open education to also be more credible, particularly by making it easy to keep material up to date through continuous feedback loops (West, 2019). In addition, open licensing of educational materials allows for remixing open educational content to better match local cultures and contexts, improving perceived credibility and usefulness of the materials (Bradshaw, et al., 2024).

Improved Quality and Innovation

In addition to improving trust and access to knowledge, openness in research and education simply makes these products better. There is some evidence that that openness leads to higher creativity and innovation (McAndrew, 2011), although more research is needed in this area. Openly sharing knowledge reduces duplication of effort as we can build off of each others’ products. This can also facilitate collaboration across disciplines and in the case of research enables secondary analysis and meta-research (a great way to train and enculturate emerging new scholars). Openness can also improve practice by providing access to research tools, tests, and instruments that practitioners can employ (Open AIMS, n.d.).

In addition, openness can support more dramatic, revolutionary changes to existing systems. For example, open science is helping to shift the focus on what constitutes quality research away from journal prestige towards actual quality of the research studies. Two examples of this is the Coalition for Advancing Research Assessment (https://www.coara.org/) and the Declaration on Research Assessment (https://sfdora.org/), which both aim to shift the evaluation of research quality away from quantitative journal metrics towards primarily qualitative, peer-based judgments that recognize the diversity of inputs into research as well as all of the diverse outputs that open science can produce, such as datasets, protocols, and processes. Recognizing that quality scientific work produces more than research articles can change incentive structures within universities in innovative ways to align better with the pursuit of quality over quantity of research output. Open science practices help scholars to document these diverse research outputs in a way that can support DORA and CORA guidelines.

Improving Access Through ALMS and FAIR Frameworks

Members of the educational technology community who promote open education are likely familiar with the ALMS framework (West & Wiley, 2024), which was developed as a guide for how "open" an open educational resource (OER) really is. The framework dictates that to be truly open, the resource should be designed in a way that anyone can remix or revise it by asking questions in four categories:

- Do people have Access to common editing tools? In other words, the simplest and most available technology should be enough to revise the resource. Practically, this means resources available in Google or Word documents are much more open than those in an obscure format.
- What is the Level of expertise required to edit? Does the open content require a high amount of expertise to edit, or can any teacher adjust or remix the resource for their teaching?
- Is the open content Meaningfully Editable? Can a teacher or learner make meaningful revisions to the resource, or is it in a format that does not allow true revision?
- Is the open content Self-sourced? Or, is the format for viewing the source the same as that for editing/revising it? For example, html can be both viewed and edited by web tools. Other formats sometimes require a different technology for editing than they do for viewing.

Similar to the ALMs framework, there is a common framework for open sharing of data, called the FAIR framework (Findable, Accessible, Interoperable, Reusable). This framework can provide useful criteria for how to FAIRly follow open science principles in one's research. Following is our summary of the FAIR criteria outlined by Wilkinson et al. (2016, 2018):

To be Findable:

Researchers should assign (meta)data a unique identifier (such as DOI) and describe the data with rich metadata. They should include in the metadata a description of the data itself and register the data and metadata in a searchable resource (such as those we describe in the next section). They should include links to their preregistration, data sources, and analysis protocols in their published final article so readers can access them.

To be Accessible:

Meta(data) should be retrievable by easy processes, and the protocol should be open, free, and discoverable, even though users may need to authenticate first (applying the ALMS framework here will help make certain that the data/materials reach the highest levels of "openness" by ensuring that anyone, using a simple web browser, can access the metadata). Metadata should be accessible even if the data is no longer available.

To be Interoperable:

(Meta)data should use broad and common language and reference other (meta)data. In short, it should be easy for machines and humans to access and use the data.

To be Reusable:

The meta(data) should be richly described with relevant attributes and released with clear data usage licenses (e.g. creative commons licenses). It should meet community guidelines for quality and clearly explain how the data was collected, how to cite it, and what its history is (e.g. was it published elsewhere).

How to be FAIR as a Researcher

Knowing the FAIR criteria for openly shared research data is the first step. But how can you apply these criteria? What resources and tools, and what processes are available to FAIRly share your research protocols, data, and articles? In this section we come to the crux of the issue—how to actually DO open science. Note that new databases are emerging every year, but as of the development of this article, this is the process we recommend for educational researchers wishing to engage in open science.

Step 1: Preregister Your Study

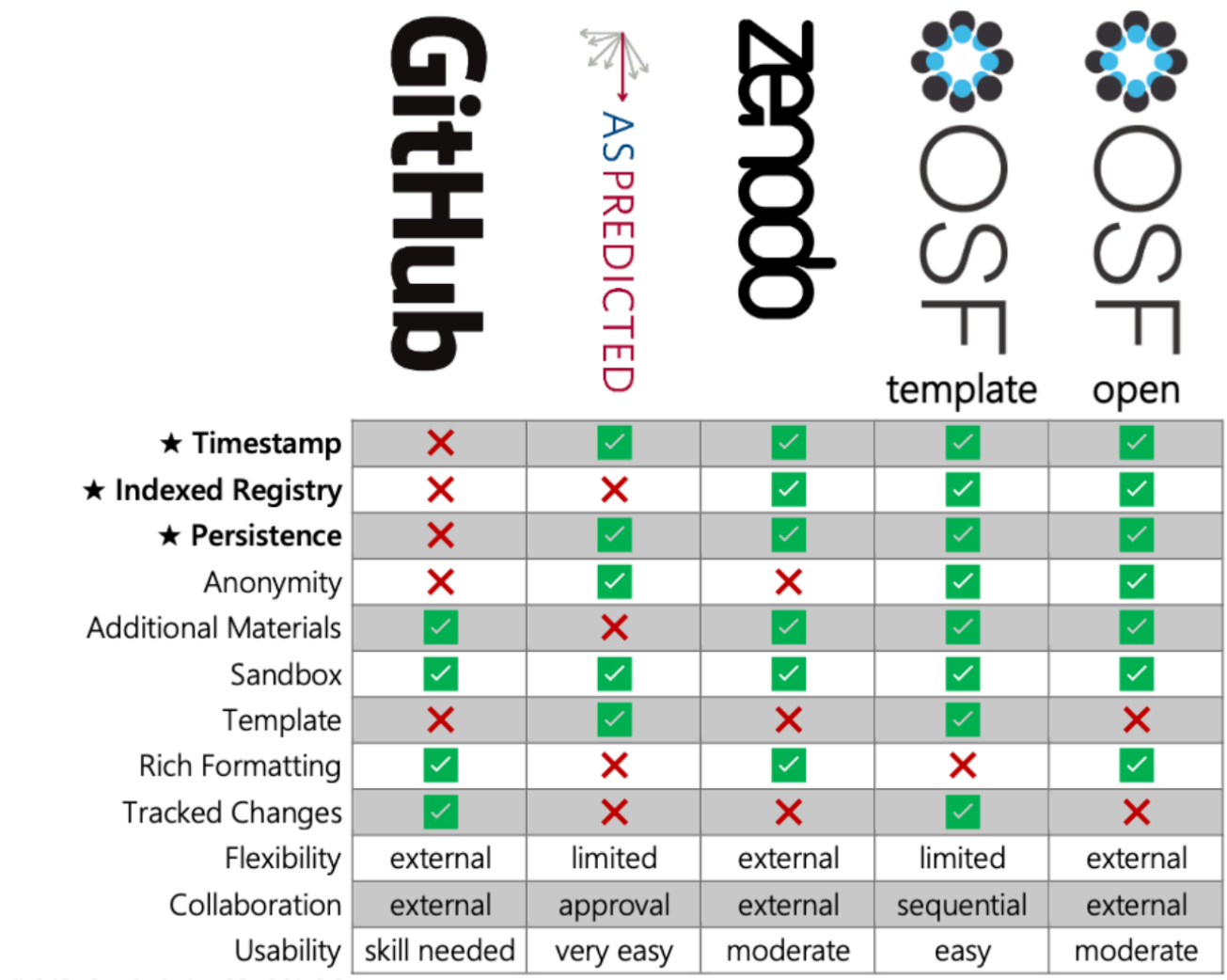
Preregistration should include three elements openly shared before the research begins: (a) research questions/hypotheses, (b) research methods, and (c) analysis plan. This communicates to others what you planned to do in the study, in order to prevent p-hacking or fishing for positive results later. It also publishes a useful scientific object in its own right as other scholars can cite and replicate your methods. Be sure to include a link to your preregistration in your final published article so that scholars can easily find it and compare it to your findings! Your preregistration should include information about your research questions/hypotheses, your methods (write these as concisely and specifically as possible), and your analysis plan. If you are doing a qualitative research study, it is also important to include a brief discussion of your positionality and prior conceptions before the study, so that readers can take your biases into account as they consider your analysis.

There are several databases available where you can preregister your study. We recommend the following:

1. OSF.io — This is the official website of the Open Science Framework and is the most extensive and detailed in the data collected as part of the preregistration. Publish here if you want the widest discoverability and reach for your study. You can see a video describing how to use OSF here.
2. **REESE (Registry of Efficacy and Effectiveness Studies)** — https://sreereg.icpsr.umich.edu/). This is a newer registry that is not as well known as OSF, but is simpler to register a study, search for studies, and quickly review the documentation on a study. Publish here if you want a good mix of discoverability and simplicity.
3. (recommended) AsPredicted.org — The simplest registry to use is AsPredicted.org, which has the benefit of having a simple step-by-step process for all three phases of open science that we discuss here (preregistration, data, and associated research artifacts). AsPredicted guides you through the process with the cleanest interface and the fewest questions (9 questions) to get at the most essential details of your study. Choose this option if you are pressed for time. While AsPredicted will give you a permanent identifying number that can be used to find your study in the database, they do not have a search feature (only a feature for looking up specific studies). Thus, discoverability is not as good as in other databases, until future iterations of the tool. However, AsPredicted is growing in popularity in psychology and social science disciplines. Practically speaking, just having the identifying protocol number from AsPredicted is sufficient as you can publish that in your article, and that is where most scholars will find out about your study.

See the following table from Steve Haroz that compares some of the different preregisteries. Available at https://doi.org/10.31222/osf.io/zry2u

Figure 1. General-purpose preregistration services features.



	GitHub	AsPredicted	Zenodo	OSF template	OSF open
★ Timestamp	✗	✓	✓	✓	✓
★ Indexed Registry	✗	✗	✓	✓	✓
★ Persistence	✗	✓	✓	✓	✓
Anonymity	✗	✓	✗	✓	✓
Additional Materials	✓	✗	✓	✓	✓
Sandbox	✓	✓	✓	✓	✓
Template	✗	✓	✗	✓	✗
Rich Formatting	✓	✗	✓	✗	✓
Tracked Changes	✓	✗	✗	✓	✗
Flexibility	external	limited	external	limited	external
Collaboration	external	approval	external	sequential	external
Usability	skill needed	very easy	moderate	easy	moderate

Note. Available from https://osf.io/preprints/metaarxiv/zry2u_v1 with a CC-BY license.

Systematic Literature Reviews

If you are doing a systematic literature review instead of a research article, preregister your methods in a registry specific for reviews. The leading registry is Prospero, but it is more focused on health care reviews and also has strict policies that would exclude many of the scoping reviews popular in the field of educational technology due to emerging nature of these technologies. Instead, consider registering your review with OSF.io or Campbell. Campbell is education and social science-focused, but is a smaller/newer registry. You can see the template to fill out to prepare for registering your review at this link: https://www.campbellcollaboration.org/get-involved/start-a-review/. Note that you must register your review early in the process before extracting data.

In describing your review protocols, if you are using a systematic process, the PRISMA protocol is the widely accepted standard to follow. Alternatively, there are other processes you can follow, such as DISCAR (West & Martin, 2024).

Preregistration Tip!

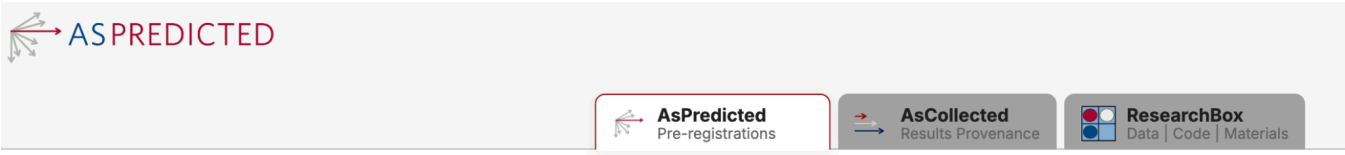
Remember that it is ok to deviate from your preregistered ideas! Just be sure to explain your reasons for doing so in your article.

Step 2: Publish Your Study Materials

In addition to preregistering your study, you should also publish the materials, instruments, code, or artificial intelligence prompts (when appropriate). This allows other scholars to use these same protocols and methods. In addition, by publishing your protocols, surveys, and measurements with an open license before conducting the study, you will prevent your measurement tool from being stuck behind paywalls after publication. While you can publish these protocols in an institutional repository for your university, we recommend instead using one of these more general tools:

1. Zenodo — Zenodo is the most well known repository for research artifacts.
2. OSF.io — OSF allows for uploading in every step of the research process, including research protocols and materials.
3. (recommended) Open AIMs on Edtechbooks — Specific to our field of educational technology, the Open Aims repository is a "book" format on EdTechBooks that publishes "chapters" for research instruments. For each instrument, the researchers can include information on validation or application studies as they accrue. The process is very simple and involves submitting a Google document. All instruments receive a doi number and CC-BY license (or a different license if you prefer).
4. (recommended) AsPredicted — AsPredicted offers the option of creating a research box to contain all the materials created as part of the research. This is the simplest interface of the registry tools.

Figure 2. The three repositories on AsPredicted.



A nice feature of AsPredicted's research boxes is their "bingo table" interface where you can cleanly share all the materials associated with different studies on the same topic, and users can click on the blue text to see an instant preview—without needing to download the files. This is a brilliant method for helping readers see how all the pieces of a research agenda fit together over time.

Figure 3. ResearchBox example on AsPredicted.

ResearchBox #15 - 'Critical Condition'

Bingo Table

Show file names
Show file IDs
Show timestamps

Select All	Pre-Registration	Materials	Data	Code	Other
Study 1			csv	STATA	zip - News sites screenshots zip - Raw data for all studies
Study 2		qsf - Qualtrics file	csv - 2a csv - 2b	STATA: 2a & 2b	
Study 3	AsPredicted #4121		csv - Study 3a csv - Study 3b	STATA: 3a & 3b	pdf - scanned responses study 3b
Study 4	AsPredicted #367	qsf - Qualtrics file	csv	STATA	
Study 5	AsPredicted #4321	qsf - Qualtrics file qsf - Qualtrics file (pilot)	csv - main study csv - Pilot	STATA	
Study 6	AsPredicted #11996	qsf - Qualtrics file	csv	STATA	
Study S1			csv		
Study S2			csv		
Study S3	AsPredicted #5151	qsf - Qualtrics file	csv		
Study S4	AsPredicted #5741	qsf - Qualtrics file	csv		
Study S5	AsPredicted #13289	qsf - Qualtrics file	csv		
Supplement				STATA - Supplements S1-S7	pdf - Supplement

Step 3: Publish Your Data and Analysis

Once you have executed your research plan and collected/analyzed data, you should then upload this data to an open repository. This allows other scholars to replicate your analysis, collect new data to compare to your data (allowing for more valuable long-term studies), and for instructors to use data sources as part of teaching new scholars. In this way, open science can feed into good open education “customs” or practices as part of the 5C framework (West & Wiley, 2024).

In order to openly share your data, first you need to be sure to structure your IRB protocol and informed consents correctly so that participants know the data will be openly shared. Second, you should anonymize the data and delete the files that contain original participant names and information. Third, it is good practice to clean up the data files to make them as usable by others as possible through having strong naming conventions and organization. This is part of making your data FAIR by focusing on interoperability and reusability. Finally, you can upload your data files to the following recommended repositories:

1. Zenodo — As mentioned, Zenodo is the most well known repository for research artifacts.
2. OSF.io — OSF remains a trusted and well-established location.
3. (recommended) AsPredicted — AsPredicted offers the option of uploading data into your Research Box, but additionally participating in their “AsCollected” section. This section shows two easy-to-understand tables that indicate which authors (represented by numbers below) participated in which stage of the research process. This helps reduce fraud by providing a permanent record about how was, and was not, participating in each stage.

Figure 4. AsCollected tables on AsPredicted.

Table 1: Author roles

	DATA			CODE					
	Raw		Final	Data Cleaning			Data Analysis		
	obtained	has copy	has copy	wrote	reviewed	has copy	wrote	reviewed	has copy
Study 1 Public data	3	2	1 2 3	3	2	1 2 3	3	2	1 2 3
Study 2 Lab data	1	1	1 2 3	1	--	1	1	--	1
Study 3 Online study	1 2 3	1 2 3	1 2 3	1	2	1 2 3	1	2	1 2 3

Table 2: Data collected

	When	Where	Data ID	Non-authors	Additional Info
Study 1 Public data	1 **Obtained** 2024-07-01	1 **Obtained from** https://moralchoice.mbc.com/archive	1 **Unique data ID?** No	1 **RAs involved** Yes	1 **Anything else:** The data are freely available from that website, and have been archived in the webarchive. **Obtaining the data**:Full-length recordings of the game show we (read more)
Study 2 Lab data	1 **From - To** 2025-06-01 2025-06-03	1 **Data source:** lab computer saving locally **Lab location:** Computer lab in [anonymized], at [anonymized]	1 **Study ID:** TEU 2025-44[anonymized]	1 **Support staff:** We received assistance from two RAs [anonymized] and the lab manager [anonymized] **Creating the dataset:** Each computer has software that saves to a networ (read more)	1 **Data cleaned:** With code **Anything else:** Nothing else.

In addition to archiving your collected data, you should also archive your data analysis. This could be your statistical output, post-hoc analyses, or in the case of qualitative data your coding/categorization tables and well-documented research journal.

Step 4: Publish Your Article Open!

The final step in open science is to make sure your article is openly available. Of course publishing in an Open Access journal (see list here: https://doaj.org/) is the best way to make your article open, but many open access journals could be considered predatory due to requiring authors to pay fees before publication (vs. making the payment of an open access fee optional). In addition, many (but not all) open access journals in the educational sciences as yet are not well established or respected yet. Hopefully the number of high quality open access journals will continue to grow.

If you publish in a journal that does not offer free open access publishing, you can still make your article freely available by uploading a “preprint” version to a repository. The preprint is generally considered to be the original version you submitted to the journal before making revisions recommended by the journal’s reviewers or editors. Many journals also allow you to upload the accepted version of the paper (after revisions, but before formatting and pagination by the journal) in specific repositories (such as arXiv) or after an embargo period. In either case, your preprint or accepted version should contain the citation to the final published version in the journal and often a specific license (check your publication agreement with the journal). In selecting a repository for your article, follow FAIR principles of accessibility by selecting a location where the maximum number of people can access without a login or account. Following are some recommended repositories for your articles:

1. Institutional repository. Most universities provide a scholars’ repository for articles. These articles will often be indexed in Google Scholar but are difficult to find if readers don’t know which institutional repository to search.
2. Zenodo.org or AsPredicted.org allow for article submissions, which can have the advantage of being attached or linked to your protocols, data, and other research elements.
3. arXiv is very popular and has a well-established history of providing access to millions of research articles. However, it focuses on certain disciplines such as math, statistics, and computer science.

4. (recommended) — In 2019, Center for Open Science (e.g. OSF.io) partnered with educational leaders to create EdArXiv. While the number of articles submitted currently is low, this is a likely candidate as the future leader for research accessibility in the field of educational research. The process of uploading a preprint is easy. First, you login with your ORCID ID, select EdArXiv as your repository, Provide the title and abstract, upload your article, and add any relevant metadata. The process takes about 5 minutes.

After publishing your article in an open repository, be sure to share it out on social media and list the link on your CV as this may be one of the best ways for others to discover your work.

Conclusion

A main argument for Open Education is that openness is a systematic issue and the more open we are in all of our work in education, the more easily open education can grow. A key aspect of this is to also be open in our research practices. Following open science principles can not only support open education by providing more openly available materials (including articles, data sets, and protocols) for teachers, but it also can foster more innovative and trustworthy science. Finally, it can increase recognition for individual scholars by making their work more discoverable.

While the ALMS framework has guided open education scholars to understand how to make open materials more accessible, in this chapter, we similarly describe how to follow open science principles by using FAIR guidelines for making every research artifact findable, accessible, interoperable, and reusable. As part of this, we outlined a four-step process to follow:

1. Preregister your research questions, data collection, and data analysis methods.
2. Publish openly your research instruments, protocols, and other study materials.
3. Openly archive your collected data and analyses..
4. Publish your article (preprint, final accepted version, or final published version) in an open access repository depending on the copyright agreement with your publisher.

In addition, supporting open science involves more than following best practices ourselves. The final step is to help make open science the norm in our research community and assist in growing the open science movement. The Center for Open Science has outlined a plan for how to help at https://www.cos.io/initiatives/prereg.

Figure 5. Center for Open Science Initiatives.



Image represents COS theory of change, available at https://www.cos.io/strategic-plan.

Currently, we have good infrastructure for doing open science, as we have outlined the common repositories in this chapter. We have also described which ones have the easiest user experience. Changing the norms and incentives will depend on all of us. Some potential ideas include asking journals if they support open science, including the sharing of preprint versions of articles and registering of protocols. In addition, scholars can create open science working groups at their universities or in their regions to assist other scholars in understanding how and why to engage in open science. There are toolkits available to help with this at https://osc-international.com/. Finally, instructors can teach open science as a separate course or as part of research courses. The Open Science Lab at the Carlos III University in Spain has created a course called "Ticket to Open Science" that could be replicated in other locations, with materials for the course already available in English. You can access the course's 10 modules here: https://www.curatore.es/uc3m2OpenScience/.

Term	Definition
5Cs framework	The five components of an open education system: competencies, content, customs, credentials, and co-intelligence.
Accessibility	How easy it is for people to access and retrieve the research object.
ALMS framework	A guide for how "open" an open educational resource (OER) is based on access to common editing tools, level of expertise needed to edit the resources, whether the open content is meaningfully editable, and whether the open content is self-sourced.
AsPredicted.org	A registry for archiving research objects with a focus on easy use and clean interface.
Campbell	An education/social science focused registry for literature reviews.
CORA	Coalition for Advancing Research Assessment (https://www.coara.org/)
Credibility crisis	A crisis in trust in research due to the lack of replicability, transparency, and ethics in research.

Term	Definition
DORA	Declaration on Research Assessment (https://sfdora.org/)
EdArXiv	An OSF location for archiving educational preprints of articles.
FAIR framework	A framework for making metadata useful by focusing on making the data findable, accessible, interoperable, and reusable.
Findability	How easy it is to find and discover the research object.
Interoperability	
Preregistration	Archiving the research plan before it is implemented, including the (a) research questions/hypotheses, (b) research methods, and (c) analysis plan
Reusability	How easily the research can be replicated due to the transparency of the methods and analysis.
Open AIMS	An open textbook or repository for archiving research instruments, assessments, and measurement tools, available on edtechbooks.org.
OSF	Open Science Framework, a popular and free location to archive research objects.
REESE	Registry of Efficacy and Effectiveness Studies, a newer registry for archiving research objects.
Zenodo	A registry for archiving research objects, including study data sets, methodology, and figures/tables.

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