Rosenberg, J. M. (2023) Open and useful? Exploring the science education resources on OER commons. *Contemporary Issues in Technology & Teacher Education, 23*(3), 490-507.

Open and Useful? Exploring the Science Education Resources on OER Commons

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Though science teachers use curricular materials from a range of sources, the nature of the science education materials that exist in the public domain or that are licensed for free use has not been the focus of much prior research. In this study, Open Educational Resources (OER) that can be accessed through the OER Commons platform were examined in terms of their characteristics and use using public Internet data mining methods. The author evaluated 8,937 life science, physical science, and applied science resources in terms of their material type, grade level, license type, number of endorsements by approved organizations (e.g., a state department of education), alignment with the Next Generation Science Standards (NGSS), and number of views. Many resources were readings and laboratory investigations, and most were for postsecondary science classes, though many were intended for high school, middle school, and elementary classrooms. Relatively few resources were endorsed, and fewer still were explicitly aligned with the NGSS, suggesting the need for greater alignment of standards across states. To provide a richer set of accessible curricular resources for educators, several implications for practice and policy are considered.

A burgeoning and important theme in educational research is the value of opening the work being done to interested stakeholders and the wider public. This need has several reasons. Educational researchers have long been challenged not only to contribute research findings or advance theory, but also to positively impact educational systems (Slavin, 2002). This challenge runs through current efforts to bring together researchers and practitioners to address pressing educational problems while concurrently contributing research or theory (Coburn & Penuel, 2016

Another need relates to the trustworthiness of educational research. This concern has motivated efforts in education to share data analytic code, materials, and manuscripts in an open and accessible manner (van der Zee & Reich, 2018), such as on a repository like the Open Science Framework. Readers of *Contemporary Issues in Technology and Teacher Education* are likely to be highly familiar with this form of openness, given that the journal is open access, permitting access to the published version of the articles to any reader with access to the Internet.

A final need pertains to the curricular materials available to teachers and students alike – a challenge that has been addressed through efforts to develop *open educational resources* (OER; Hewlett Foundation 2022). Each of these attempts to open educational research is in service of a different aim, but they share features, including a commitment to the sharing of resources and materials whenever possible to benefit the educational system.

When considering efforts to open science education research, the emphasis on research-practice partnerships is evident — see Edelson et al., (2021) ,Farrell et al. (2022), Marshall et al. (2021), and Penuel (2017), for several examples. Furthermore, there have been efforts to engage in open science in science education (Kessler et al., 2021; Nosek et al., 2019).

In considering the development of OER, several examples may be presented, with the OpenSciEd curriculum development project (see OpenSciEd, 2022a) as the most visible and noteworthy. An important feature of OpenSciEd is that it represents the development of whole units of curricular materials. These units are thoughtfully developed and are likely highly useful to many science educators, but surveys indicate that teachers turn to a wide range of curricular materials, including sources that provide one-off activities or lesson plans that teachers can use to augment their instruction (Polikoff & Dean, 2019; Tuma et al., 2022).

From this vantage, it appears that studies of OER available through a range of sources — teachers' blogs, social media, and even commercial platforms such as TeachersPayTeachers —have not been paid very much attention, though they may be widely used by science educators. Thus, though efforts to open science education research are prominent, less research has considered the roles of OER in science education. but OER can be important. Smith and Casserly (2006) captured the values underlying these efforts across education: "At the heart of the open-educational resources movement is the simple and powerful idea that the world's knowledge is a public good" (p. 10). Further, these authors highlighted how these efforts draw on positive features of technology, writing that "technology in general and the World Wide Web, in particular provide an extraordinary opportunity for everyone to share, use, and reuse that knowledge" (p. 10).

OER can be seen as a means of making greater knowledge accessible to teachers and learners. In this way, OER can be a — perhaps *the* — primary way that efforts to open education are relevant to most science educators and science education researchers, especially those with an interest in the use of technology in the discipline.

This topic and the aim of arguing in favor of the importance of OER for future research and development are the focus of this paper. In the next section, prior research on OER in education (widely) and in science education (specifically) is considered. Following this review is an empirical investigation into the OER available for science educators on one of the most widely used platforms for OER, OER Commons.

Literature Review

The Provenance, Availability, and Quality of OER

OER are "teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and re-purposing by others" (Hewlett Foundation, 2020, para. 4). These resources range from courses and books to tests and technologies. By being open, they are not only available to others to use, but also to reuse, redistribute (or share), revise (adapt or change the work), and remix (combining existing resources to create a new one; Hilton et al., 2010).

OER have been well-researched for nearly a decade and a half, especially at the postsecondary level. Research has found that students and instructors positively perceived OER relative to for-purchase textbooks (Hilton, 2016), though there is variation in effectiveness based on characteristics of both students and course modality (Clinton-Lisell, 2022). Further, research has documented how students typically achieve similar learning outcomes when using OER textbooks relative to students using commercial textbooks.

Though less research has been conducted at the K-12 than at the postsecondary level (perhaps because the motivation for many investigations into OER is to enhance the affordability of postsecondary education for students by not requiring them to purchase pricey textbooks), some research has been conducted. One prominent study demonstrated that students using OER textbooks in high school science (earth science, chemistry, and physics) classes demonstrated greater achievement, as measured through standardized tests (Robinson et al., 2014).

In sum, OER textbooks have generally been found to be appropriate replacements for traditional textbooks in terms of student and instructor (or teacher) perceptions of their effectiveness and in terms of student achievement when using them. A key benefit of OER is that they do not need to be purchased either by students or K-12 institutions, which can use the funding for textbooks for other purposes, such as laboratory and investigation-related materials.

While there has been research into the effectiveness of OER textbooks, teachers regularly supplement what is in their textbooks with additional materials. Some research has investigated teachers' perceptions of the materials available through various platforms and marketplaces — especially TeachersPayTeachers. For instance, Aguilar et al. (2022) examined the contents of practically all of the English/language arts and

mathematics materials (lesson and unit plans, printables/worksheets, and assessments, among other types) on the commercial platform Teachers Pay Teachers using educational data mining methods. They found that the more than 500,000 resources were primarily for elementary teachers, and a relatively small percentage (40%) were aligned with the national *Common Core State Standards* (National Governors Association, 2010**)**

Other studies using similar data mining methods have found that some of the most-downloaded resources on TeachersPayTeachers were "ready-to-go, fun materials," along with decorative items (e.g., bullet board ideas; Shelton et al., 2022). Though educators report that TeachersPayTeachers help them to address the limitations of the materials available to them (Carpenter & Shelton, 2022), their quality (at least for social studies resources) is questionable (Harris et al., 2022).

Further, TeachersPayTeachers has been found to be unequal in terms of the rewards earned by the educators who list their materials on the platform: a remarkable 81% of sales are attributable to the top 1% of sellers (Koehler et al., 2020). In the context of the generally positive findings associated with OER, there has been more critical research into the prominent TeachersPayTeachers platform.

Apart from textbooks and resources through TeachersPayTeachers, teachers access materials from a range of other sources, including trusted colleagues, professional development providers, and the websites of professional organizations, social media, and other platforms (Hodge et al., 2019; Polikoff, 2019; Rosenberg et al., 2020; Tuma et al., 2022). One platform that is the focus of this study is OER Commons. Though perhaps the most prominent for OER resources in a manner akin to how TeachersPayTeachers hosts resources for sale, this platform with strictly freely accessible resources has not been the focus of any prior research.

Open Materials and OER in Science Education

There has been less research into open materials and OER in grades K-12 science classrooms — except for Robinson's (2014) study of the effectiveness of OER textbooks in terms of students' achievement. However, this does not mean that science education researchers and science educators do not value or use open materials and OER. There is a long history of science education researchers creating and sharing curricular materials. Consider the three journals for K-12 science teachers published by the National Science Teaching Association (NSTA; *The Science Teacher, Science Scope*, and *Science & Children*), each of which includes articles with research-based teaching strategies, lesson or unit ideas, and other resources.

Other examples of the creation of materials include developing entire curricula, such as the IQWST project-based curricula (Krajcik et al., 2008). A possible criticism that could be levied against these efforts to share resources and curricula is that they are often partially or entirely unavailable except to those who pay for or already have access to them. To read articles in the NSTA journals, a science teacher must be an NSTA member; to use IQWST, an educator's district or school must purchase it.

Though numerous exceptions exist, and doubtlessly most science education researchers and curriculum developers would like to share what they design and develop more widely, many research-based curricular materials are not freely accessible.

The challenge of the accessibility of high-quality materials has been recognized by researchers and practitioners alike. One response has been the OpenSciEd project, a project focused on developing and providing "high quality, NGSS-aligned science materials and outstanding professional learning support" (OpenSciEd, 2022a, para. 2). Funded by a range of organizations, including the Hewlett Foundation (that has funded other OER-related projects), "all of the OpenSciEd units are being designed as Open Educational Resources" (OpenSciEd, 2022b, para. 20).

OpenSciEd can be seen as a project following the mold of early OER advocates who wrote about the importance of freely sharing and making accessible knowledge (e.g., Smith & Casserly, 2006); OpenSciEd's website notes that the organization "exists to combat inequities in education by providing high-quality science learning experiences for all students" (OpenSciEd, 2022a, para 9.) Because of the number of units now available as OER and the careful design and development that undergirded their release (Edelson et al., 2021), OpenSciEd is the most prominent and important OER-related project in K-12 science education to date.

Purpose and the Present Study

OpenSciEd is an important OER for science teachers, but it is likely not the only source teachers turn to for curricular resources, especially as OpenSciEd has developed materials only for middle grades teachers. Among the many sources available to science teachers, OER Commons may be an important and central one: It contains resources for every content area and grade level and allows for organizations or units (e.g., state departments of education and nonprofit organizations) to share all their materials via a central, easy-to-use platform. Further, the kinds of materials available through OER Commons could serve as a complement to what OpenSciEd creates: where OpenSciEd creates entire units developed with a coherent ("storyline") approach (Edelson, 2020), educators may turn to resource marketplaces to fill gaps or supplement the curriculum or textbook they are provided (Carpenter & Shelton, 2022).

For this reason, examining the science education contents of OER Commons may reveal a fuller picture in terms of the OER available for science teachers. Further, such an examination may reveal gaps in terms of research or curriculum design and development that could be addressed in future work.

In the study reported in this paper, the importance of OER for science educators was considered through an exploration of a prominent platform for the creation and sharing of such materials: OER Commons. OER Commons is "a public digital library" (OER Commons, para. 1) of OER that educators can freely access and, in most cases, use, modify, and share in modified form. Though the platform has many thousands of resources shared over more than a decade, no research has documented *what* is

accessible with respect to science education and how widely *used* these materials might be. The research questions that guide this study, then, were as follows:

1. What are the characteristics of the resources that are accessible through the OER Commons website?
2. How widely used are these resources?

An examination of the availability and use of such resources can help to fill in the field's understanding of the ecosystem of materials available to science educators, which can contribute to research and further developments that enhance what is available to science educators to the ultimate benefit of science students.

Method

Methodology

This study used a public Internet data miningapproach (Kimmons & Veletsianos, 2018) akin to that used in data mining studies of TeachersPayTeachers (Aguilar et al., 2022; Koehler et al., 2020; Shelton et al., 2021). Specifically, this study involved using the contents of the OER Commons website as a source of data that can be used to understand what is available to science educators on the platform. One benefit of using this methodological approach is the capability to access a large collection of posts in a manner that would be highly impractical to carry out using manual data collection processes. Another benefit of this approach is the nonresponsiveness to the study of the platform and its users: possible sources of bias that may accompany asking the creators of content on OER Commons to self-report on what they have created and shared are not present.

While much information about resources on the platform is available, other information is not. Thus, a downside of this methodological approach is being limited to the contents of the site and not being able to inquire of creators or users of the platform about how they perceive and use resources. Despite this negative feature, this study was intended to present a first, exploratory view into which OER are available on this platform in a way that can provide ideas for further research.

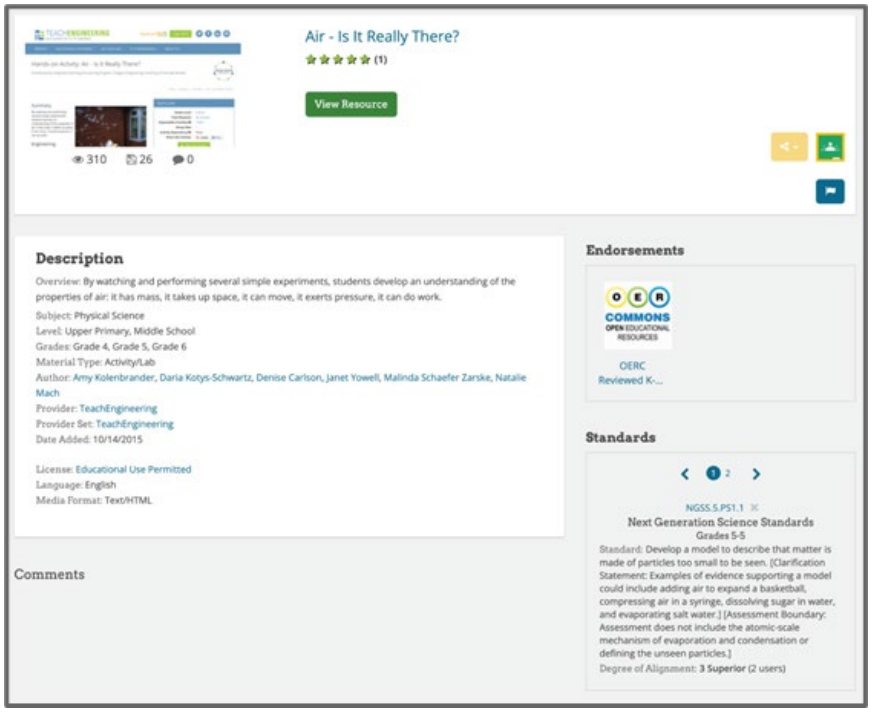
Data Source and Sample

The sample for this study consisted of all the science education resources available on the OER Commons website as of December 2022. First, all the resources on the OER Commons website were accessed using web scraping methods. Specifically, the URL for each resource was identified by iterating through each page of resources on a subject-by-subject basis, as this is the primary way that resources are presented on the website. This step and all subsequent analyses were carried out using the statistical software and programming language R (R Core Team, 2022). After each resource's URL was identified, the HTML for the resource was saved. Then, the information on each saved page was queried for specific

information, including the resource's subject(s), title, material type, grade level, license type, endorsements, standard(s), and views.

Figure 1 is a screenshot of an example resource – one labeled as physical science. The title ("Air - Is It Really There?") is near the top and at the center of the page. "View Resource" is a unique link to the resource. The five green stars indicate that one user has rated this resource as five out of five possible stars. The resource was viewed (as measured by the "View Resource" link being clicked) 310 times (and "saved" by users within their accounts 26 times, though this information was not used in the analysis). The level, material type, and license are noted beneath this information and the single endorsement, and two associated standards are provided on the right side of the page.

Figure 1
Example Physical Science Resource From OER Commons



The result of identifying and recording information for each resource was the creation of a common-separated values file (spreadsheet) with information on 48,496 distinct projects available on OER Commons. To determine which projects were science-related, the labels for the subject or subjects for the resource were used. Specifically, any resource labeled with one or more of the following three subjects was a science education resource: physical science (including the earth sciences), life science, and applied science (which includes engineering, environmental science, and the health sciences); none of the other subjects were directly related to science. It was determined that 8,937 resources (18.4% of all resources on the website) were science related; 6,208 (69.5%) were life sciences

resources; 1,950 (21.8%), applied science; and 1,940 (21.7%), physical science.

Data Analysis

To analyze data to answer Research Question 1 (about the characteristics of available resources), the following information was descriptively analyzed by presenting the counts and the proportions of resources by characteristic:

- *Material type*: The type of resource, such as "Activity/lab," "Assessment," and "Lesson" (21 total).
- *Grade level*: The grade level, such as Middle School and High School (10 total).
- *License type*: The copyright license for the resource, such as one of the several Creative Commons licenses (15 total).
- *Number of Endorsements*: The number of recognitions of a supported or approved resource from state departments of education and other organizations recognized on the OER Commons websites.
- *Standards*: The standard or standdards to which the resource is aligned; for the purpose of this analysis, alignment with any of the NGSS (NGSS Lead States, 2013) was determined.

To analyze the data for Research Question 2 (about how widely used the resources are), the mean number of Views — that is, the number of times a user accessed the resource via its unique link — were calculated for each specific group for the material type, grade level, and license type characteristic. The same mean number of views was calculated based on the number of endorsements and the presence of one or more aligned standards relative none.

Findings

The findings for the two research questions are presented by characteristic (e.g., the material type). Across all projects, the mean number of views per resource was 52.0, but there was substantial variability between resources (SD = 540.2, $min.$ = 0, $max.$ = 47,425).

Material Type

The plurality of resources were readings, 2,840 (constituting 31.8% of all science education resources; Table 1). Notably, on average, these resources received few views — an average of only 4.2 per resource, which indicates that most readings were likely being directly used from OER Commons by a few individuals. Readings were followed by a material type likely familiar and of interest to many science educators —]activities and laboratory investigations — of which there were 1,694 (19.0% of all resources). These were viewed by far more users, on average, 60.6 per resource. Modules, lessons, and case studies were the next most common. Simulations, interactives, and textbooks, all commonly used by science educators for different purposes, were relatively uncommon on OER Commons.

Table 1
The Count, Proportion, and Mean Number of Views per Material Type

Material Type	*n*	%	*M* views
Reading	2840	31.8	4.2
Activity/Lab	1694	19.0	60.6
Module	860	9.6	235.2
Lesson	792	8.9	15.2
Case Study	788	8.8	1.7
Lesson Plan	549	6.1	59.6
Lecture	447	5.0	28.6
Diagram/Illustration	436	4.9	44.4
Full Course	254	2.8	223.8
Assessment	253	2.8	48.0
Simulation	219	2.5	7.6
Interactive	171	1.9	23.0
Textbook	94	1.1	148.1
Teaching/Learning Strategy	90	1.0	82.4
Homework/Assignment	86	1.0	106.8
Unit of Study	85	1.0	55.4
Note. The five material types that comprised less than 1.0% of all resources were not included in this table.			

Grade Level

Most resources were intended to be used at the upper division of college and the lower division of community college, with 4,893 (54.7%) and 4,847 (54.2%) of resources being associated with one or both of these grade levels (as resources could be labeled with multiple intended levels; Table 2). Notably, relatively few resources were geared toward the elementary context, with 1,130 (12.6%) resources for the upper primary grades, and 662 (7.4% for the lower primary grades. Fewer still were available for preschool educators: 113 (1.3%). There were not great differences in terms of the average number of views per level, though the relatively few resources available for adult education and preschool levels received greater views, on average than the other grade levels.

License Type

Together, Creative Commons licenses were used for 6,671 (74.6%) resources (Table 3), a license type that is generally permissive in terms of allowing for use and reuse. The most used Creative Commons license was Attribution Non-Commercial Share Alike, which allows anyone in the world to use and modify (i.e., reuse) the resource so long as (a) they do so for noncommercial purposes and (b) they share any modified resources with this license. The second most used license was Creative Commons Attribution Non-Commercial — like the most commonly used license, but not stipulating that modified resources must be shared with the same license.

Table 2
The Count, Proportion, and Mean Number of Views Per Grade Level

Grade Level	*n*	%	*M* views
College / Upper Division	4,893	54.7	55.4
Community College / Lower Division	4,847	54.2	65.8
High School	2,818	31.5	41.0
Career / Technical	2,555	25.6	17.4
Graduate / Professional	1,906	21.3	16.3
Middle School	1,875	21.0	34.7
Upper Primary	1,130	12.6	60.9
Lower Primary	662	7.4	58.0
Adult Education	206	2.3	110.9
Preschool	113	1.3	75.1

The third most used license, Attribution, is similar to the second most commonly used one, but it also allows for commercial uses. The fourth most commonly used license, Some Rights Reserved, bears a semblance to traditional copyright, reserving some rights. It is a license type used by the Creative Commons organization to allow the creators of resources to share their materials while retaining individual creator-selected rights related to their work (Creative Commons, 2022). Notably, the Educational Use Permitted designationtypically refers to a traditionally copyrighted material, albeit one that explicitly recognizes that the material can be used for educational purposes.

While resources associated with the reservation of some rights received few views (an average of only 0.5 per resource), those that explicitly permitted educational use received far more (118.5 per resource), suggesting that the observable differences in views by license type are likely due to another factor.

Table 3
The Count, Proportion, and Mean Number of Views Per Grade Level

Grade Level	*n*	%	*M* views
College / Upper Division	4,893	54.7	55.4
Community College / Lower Division	4,847	54.2	65.8
High School	2,818	31.5	41.0
Career / Technical	2,555	25.6	17.4
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Upper Primary	1,130	12.6	60.9
Lower Primary	662	7.4	58.0
Adult Education	206	2.3	110.9
Preschool	113	1.3	75.1

Number of Endorsements

Most resources, 8,180 (91.5%), received no endorsements (e.g., from a state department of education recognizing a resource as high-quality or created by their curriculum developers); 691 (7.7) received one endorsement, and fewer still received two, three, or four resources. There was not a clear association between the mean number of views and the number of endorsements a resource received.

Table 4
The Count, Proportion, and Mean Number of Views Per the Number of Endorsements

Number of Endorsements	*n*	%	*M* Views
0	8,180	91.5	37.0
1	691	7.7	46.0
2	59	0.7	838.7
3	6	0.1	67.8
4	1	0.0	129.0

Standards

Finally, the great majority of resources were not aligned to the NGSS: 8,554 (95.7%) did not explicitly indicate alignment with any of the NGSS; 195 (2.2%) indicated alignment with one standard, and 188 (2.1%) indicated alignment with two or more standards, indicating that just over 4% of resources were aligned to the NGSS.

Table 5

The Count, Proportion, and Mean Number of Views Per the Number of Aligned Standards

No. of aligned standards (NGSS)	*n*	%	*M* views
0	8,554	95.7	41.3
1	195	2.2	72.2
2+	188	2.1	89.2

Discussion

Key Findings

Many resources on OER Commons are intended for science educators and most of these resources are of a different type than the most prominent OER project in science education — OpenSciEd — as most resources are readings and activities and laboratory investigations. Though these two material types are a part of OpenSciEd curricula (Edelson, 2021), those offered through OER Commons stand apart and likely serve a different purpose for teachers — filling specific gaps in their curricula (Carpenter &

Shelton, 2022). Few textbooks are available, though this may be a function of the amount of time required to create a textbook relative to a single activity.

In sum, though many resources are available to science educators as OER through the OER Commons platforms, they appear to be of a kind similar those available through the commercial TeachersPayTeachers platform (Aguilar et al., 2020; Shelton et al., 2022); that is, primarily for filling specific instructional needs rather than an entire curriculum. Like for materials on TeachersPayTeachers, it may be essential to assess their quality (Harris et al., 2022).

Also different from OpenSciEd is the predominance of OER Commons materials intended for postsecondary science educators. This finding is in accordance with how prior research on OER has predominantly been set in college classrooms (Hilton, 2016) — see Robinson et al. (2014) and Clinton-Lisell (2022) as examples. Many resources on OER Commons are available for high school, middle school, and elementary school educators, but these resources are less abundant than those for the instructors of classes at the college level, particularly at the advanced level. This finding suggests there may be value in heightening OER at the K-12 level on the part of educational leaders, teacher educators, and policymakers.

The licenses mostly allowed for materials to be accessed, used, and modified, as allowed for by Creative Commons licenses. Around three-quarters of materials had such licenses, though with some differences regarding the commercial use of resources, how those who modify resources must license their work, and whether the creator of the resource must receive attribution. Some resources used licenses that were less permissive in nature. Indeed, some noted only that educational use is permitted, implicitly reserving all other rights protected under copyright protections.

It is not evident what an ideal proportion of resources with Creative Commons licenses should be, apart from definitions of OER that highlight the importance of resources having a license that permits the free use and repurposing by any individual (Hewlett Foundation, 2022). Perhaps materials with some rights reserved or those labeled as allowing educational use may not be accessible at all were they not shared with these licenses, and so it may be better to share them with these relatively restrictive licenses than not at all.

Most resources, greater than 90%, were not endorsed by any approved organization, though many were. Resources that received greater endorsements generally were viewed more. Significant variation was found in the number of views seen by resources with greater than two endorsements, possibly due to the relatively few resources with more than two endorsements (and some receiving many views). Similarly, most resources, around 96%, were not explicitly aligned to the NGSS.

It is important to note that many of these approximately 96% of resources did reference a standard — typically, state-specific standards (e.g., the Michigan K-12 Science Standards). Given that 44 states have adopted either the NGSS or standards based upon the NGSS, but practically all the

states that have adopted standards based on the NGSS use similar but distinct standards, it is likely that far more than 4% of the resources available through OER Commons could align to the NGSS. Nevertheless, the absence of an explicit alignment of many resources to the NGSS suggests that resources may be used more locally (e.g., primarily in a single state, like Michigan) even though the resources could be useful to a wider, national audience of teachers. This finding suggests that efforts to align standards across states could enhance the usability of resources.

Limitations and Recommendations for Future Research

As suggested earlier, this study was intended to provide an overview of what materials are accessible and the degree of use of resources. Questions about the quality (or the perception of quality) and the ways educators use the OER available through OER Commons are difficult to answer using the public Internet data mining methods employed due to the intrinsic limitations of solely using this method. Future research may interrogate the quality of resources using techniques like those used by Harris et al. (2021) to interrogate the quality of materials on TeachersPayTeachers: coding a sample of resources using validated rubrics. Another direction for future research is to consider the other sources teachers turn to for resources, including social media groups and connections and the websites of professional organizations. Such research could reveal the relative frequency with which science teachers use different platforms and the affordances and constraints of accessing resources on them.

Implications for Practice and Policy

One direction for practice is to value OER to a greater extent. Though these findings suggest that resources on OER Commons are viewed (and likely used) by many educators, a comparison with TeachersPayTeachers can be productive for considering how OER Commons might be even more useful. Research suggests that as of 2019 TeachersPayTeachers hosted nearly five million resources (Koehler et al., 2021; Shelton et al., 2022) — around two orders of magnitude more resources than OER Commons, which hosts around 50,000 resources. One reason for this may be that teachers were incentivized to share materials because they could be paid for doing so. Over time, the platform became well-known, further incentivizing teachers to share their resources — or to share greater or enhance their existing resources. Such a process through which a platform becomes widely used may be less likely to take place with OER Commons — a platform "rooted in the human right to access high-quality education" (OER Commons, 2022, para. 1).

Further, the processes that have led TeachersPayTeachers to become so established has downsides, too, including questions about the quality and standards alignment of resources (Aguilar et al., 2022; Harris et al., 2021; Shelton et al., 2021) and the high degree of income inequality among sellers, with relatively few educators reaping most of the benefits of selling on the platform. Thus, there could be value in incentivizing the sharing of OER on platforms such as OER Commons instead of on TeachersPayTeachers, but doing so is challenging.

Most teachers are paid less than the prevailing wages for professionals with similar educational backgrounds and experiences (Allegretto, 2022). One way to incentivize the sharing of OER is for educational leaders, including those based in schools and in district central offices, to recognize the sharing of OER in teachers' annual evaluation processes. Similarly, the creation of OER could be incentivized by institutions of higher education valuing faculty sharing OER for the use of other educators at the K-12 or postsecondary levels. There are likely other ways that OER could be valued more, and future research can accompany this implication for practice.

At the policy level, educational leaders, representatives of nonprofit organizations and grant funding agencies, and policymakers can consider the ecosystem of curricular materials available to teachers when allocating funding. The OpenSciEd project demonstrates some of the positive impacts of funding the development of OER: OpenSciEd materials are used by thousands of science teachers across the United States (OpenSciEd, 2022a). Recognizing or providing funding for a greater range of OER creators (including "master" teachers) and a greater range of the types of OER could contribute to the existence greater options available to teachers. Making more high-quality resources freely available resources could be especially valuable to early-career science teachers but would also likely have benefits for educators at all career stages.

Conclusion

Multiple reasons have impelled educational researchers to make their design, development, and research efforts more open. An important initiative related to opening educational research is OER, resources that are available to teachers and students anywhere who can access them, typically via computers or mobile devices connected requiring only a connection to the Internet. The creation and use of OER are accompanied by commitments to the importance of sharing knowledge as it is represented in curricular resources.

This paper reviewed prior research on OER in education, pointing to the generally positive findings related to educators' and students' perceptions of OER and the effects of using OER on student outcomes. This paper also considered research on other sources teachers turn to for curricular resources to establish the need to examine one of the most prominent platforms for OER, OER Commons. Examining the science education resources on OER Commons revealed that readings and activities and laboratory investigations are common, and that most resources are intended for use in college classrooms, though there is a great range of material types for a myriad of grade levels available through the platforms. Most resources are not endorsed, and few are aligned to the NGSS, suggesting that steps could be taken to heighten the value of OER. Future research into the curricular resources teachers seek out can help to make high-quality materials available to a greater number of science teachers and learners.

Author Note

This research was carried out with support from the William and Flora Hewlett Foundation as part of the Open Educational Resources (OER) Research Fellows program.

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