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Understanding how professional development opportunities affect open educational resource sharing

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Background: Open Educational Resources (OERs) help instructors create innovative lessons and foster cost-effective and equitable access to educational materials. As more instructors turn to OERs to enhance their courses, there is a growing demand for the creation of more lesson plans.

Methods: To increase the number of high-quality OERs in undergraduate biology and physics, the journal *CourseSource* introduced Writing Studios to assist educators in writing and publishing OERs. Over a period of 5 years, 188 attendees participated in one of 11 different Writing Studios in which they followed a scaffolded worksheet to help draft their OER and engaged in peer review with partners. Attendees completed surveys before and after participation, and we tracked whether or not they published their manuscripts.

Results: We found that 38.8% of attendees shared their OERs through a *CourseSource* publication. Several characteristics predicted OER sharing through publication such as format of the workshop and attendee's type of institution. Participants also described a variety of supports and barriers that impacted their ability to publish as well as possible long-term supports that would help bring resources to publication.

Discussion: This study highlights the importance of ongoing support and tailored strategies to facilitate the sharing of OERs. The findings can benefit instructors and professional development leaders who are committed to increasing the number of high-quality resources that are available.

KEYWORDS

***CourseSource*, workshop, biology lessons, publishing, online**

1 Introduction

Instructors often seek materials and examples of student-centered teaching to enhance their courses. Open Educational Resources (OERs) offer support to instructors by providing adaptable, open-access teaching and learning content "that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaptation, and redistribution by others" (UNESCO, 2019, p. 5). These

permissions allow authors and users to adapt and redistribute content to suit their needs, at no cost (Wiley, 2007, 2014).

OERs include a wide variety of course materials such as textbooks, lecture slides, classroom activities, assessments, multimedia assets (e.g., images, videos, and animations), software (e.g., simulations), and games. Since OERs are available at no-cost, they provide more equitable opportunities to students regardless of their socioeconomic status, including increased access to educational materials such as textbooks (Hilton and Wiley, 2011; Griffiths et al., 2018). For educators, OERs provide increased course development support (Caudill, 2011) and the potential to share and reuse resources. Thus, OERs can improve the quality of content development since educators can adapt available OERs for their specific needs (Hylén, 2006).

Creating OERs is an iterative and often nonlinear process of development, use, and improvement (Gurell, 2008). This process, commonly referred to as the OER life cycle, involves several key steps for the instructor (Figure 1): (1) searching for resources, (2) evaluating the suitability and adaptability of the identified resources, (3) adapting the OER to the local context and/or specific use, (4) using the newly adjusted OER, and (5) sharing the modified OER back with the community (Clements and Pawlowski, 2011). In addition, the OER life cycle can begin with an instructor creating a new resource, using it in the classroom, and then sharing their field-tested OER in a variety of ways, such as publicly posting to an OER repository or sharing privately with colleagues (Figure 1; Beaven, 2018; Kleinschmit et al., 2023).

Most research on instructor OER engagement focuses on the Search, Evaluate, Adapt, and Use steps of the OER life cycle (Bateman et al., 2012; Hassler et al., 2014). Less is known about the Share step (Beaven, 2018), which can take multiple forms. At a basic level, sharing can be defined as making a resource available to a community, which can include a range of activities from informally sharing materials with colleagues to publishing a manuscript in a public forum (Clements and Pawlowski, 2011). A recent qualitative study found that undergraduate instructors used and adapted resources from an OER repository and created original resources. However, rather than resharing those materials back to the repository or to another open access resource, instructors primarily shared their resources privately with colleagues and students (Beaven, 2018). A survey of over 1,500 Dutch teachers from primary, secondary, and higher education similarly showed that although most teachers share OERs, the sharing is infrequent and more often occurs between colleagues than with a broader audience, such as posting to an online database (Van Acker et al., 2014). Individuals may be more likely to share their materials online when they feel they have something valuable to contribute (Van Acker et al., 2014) or when quality control processes (e.g., peer review) are robust (Windle et al., 2010). Furthermore, a previous study showed that only 28% of undergraduate biology instructors who use OERs engage in sharing through publications (Senn et al., 2022).

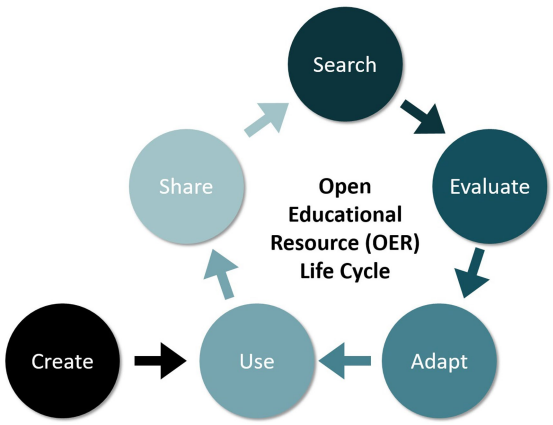

FIGURE 1
The OER life cycle (adapted from Clements and Pawlowski, 2011).

One common model for sharing OERs is through professional development programs that facilitate developing OERs within communities of practice. Communities of practice are defined as groups of people who have a common interest or concern and come together to learn from one another, develop skills, and further their conceptual understanding (Wenger, 2011). Research suggests that the greatest driver for sharing OERs is through engagement in a community of practice where members feel a sense of achievement, ownership, and support (Windle et al., 2010). Indeed, instructors working in groups have greater success engaging in the OER life cycle (e.g., adapting and sharing) than individuals (Lane and McAndrew, 2010). For example, Kleinschmit et al. (2023) showcase the effectiveness of using communities of practice to collaboratively create vetted OERs and train faculty on implementation. Specifically, incubators focus on developing content, faculty mentoring networks adapt and disseminate the OERs, and education research communities study student learning and refine assessment instruments.

To expand the availability of field-tested OERs, we designed a professional development program that ran from 2018 to 2023, specifically focused on supporting participants in writing and publishing an article in the OER journal, *CourseSource* (see section "Methods" for more information about this journal). We offered both short-term (in-person or online) and long-term (online only) versions of this program, hereafter referred to as Writing Studios.

We developed the Writing Studios based on the Reflective Teachers Change Strategy model, which focuses on improving instructional practices through reflection on knowledge, experience, and skills (Henderson et al., 2011). In this model, a facilitator's primary role is to encourage and support reflective practices while participants develop new instructional strategies. Although not required, facilitators may also provide information, materials, and resources on instructional strategies. Literature on this topic suggests that several factors support the development of reflective teachers: peer support (Lynd-Balta et al., 2006), engaging in reflective practices, and transitioning beliefs and conceptions from teacher-centered to student-centered (Henderson et al., 2011). Thus, the Writing Studios were designed to help participants critically reflect on their own teaching and engage in discussion with peers while facilitators provided guidance and support.

Because less is known about the Share component of the OER life cycle, we have focused on gathering information from participants who attended various versions of the Writing Studios to answer the following research questions:

1 What characteristics predict whether participants share their OERs through a *CourseSource* publication?
2 In what ways does participation in a *CourseSource* Writing Studio focused on OER publication help participants achieve their goals?
3 What long-term supports do participants perceive are necessary to successfully share their work through publication?

Our findings provide insights regarding successful sharing of OERs and the supportive mechanisms necessary for achieving publication goals.

2 Methods

2.1 Participants

This study focuses on 188 participants who attended one of 11 different Writing Studios. These participants were invited to apply for a Writing Studio through email announcements to listservs (e.g., Society for the Advancement of Biology Education Research, Biology Education Intersegmental Collaborative), groups that focus on community college education (e.g., Community College Bio INSITES), blog posts, and social media. To apply, participants answered questions about their institution, career stage, and potential manuscript topics. Recruitment for the workshops prioritized first-time authors to *CourseSource*. A description of participant demographics information is shown in Table 1.

2.2 The OER journal *CourseSource*

CourseSource is a journal created to provide peer-reviewed and field-tested curricula that emphasize active learning approaches in the undergraduate life sciences (CourseSource, 2024). *CourseSource* articles are open-access, and readers can download all resources (e.g., slides, worksheets, clicker questions) by creating a free account. All "Lesson" articles must follow a comprehensive template that ensures the activities and lessons are detailed enough to be reproducible by novice instructors. The lessons and techniques described in the articles employ evidence-based, active learning strategies known to decrease failure rates, increase student learning, and provide equitable opportunities for underrepresented students (Eddy and Hogan, 2014; Freeman et al., 2014; Theobald et al., 2020). *CourseSource* articles are open access and have a CC BY-NC-SA 4.0 DEED Attribution-NonCommercial-ShareAlike 4.0 International license.[1] To help with the costs of maintaining the journal, $400 page charges were introduced in 2023. However, Writing Studio participants received a waiver for page charges.

TABLE 1 Demographic information and participation in Writing Studio variations ($N = 188$).

Category	Participants (% of total)
Participant institution type	
Community College	10.1
Primarily Undergraduate Institution (PUI)	21.3
Master's–Granting University	9.0
Doctorate–Granting University	59.6
Participant career stage	
Graduate student	13.3
Postdoc	10.6
Faculty	74.5
Other (e.g., staff, undergraduate)	1.6
Writing Studio modality and length	
In-Person Short ($n = 3$)	41.0
Online Short ($n = 5$)	45.7
Online Long ($n = 3$)	13.3

2.3 Writing Studio versions

The Writing Studios were designed to help participants develop a manuscript for publication on an OER lesson they had already designed and taught. The goal of the Writing Studio was to give participants enough information and writing time to have a solid draft by the end of the workshop.

To keep participants organized during the workshop, they followed a worksheet designed to scaffold each section of the writing process (Supplementary material). For each part of the worksheet, the facilitators described the relevant article section, answered questions, and provided individual writing time. Attendees then peer-reviewed each section in pairs and engaged in whole group discussions. Three versions of the Writing Studio were implemented for this study: (1) In-Person Short, (2) Online Short, and (3) Online Long (Table 1). In-person Writing Studios occurred over three consecutive days before an education conference and are categorized as "In-Person Short." During the lockdown portion of the COVID-19 pandemic (2020–2021), three-day Writing Studios were offered online and are categorized as "Online Short." Online Short workshops followed the same general format as in-person, using Zoom for whole group discussions and breakout rooms for peer discussions. Long versions of the Writing Studios were offered over a semester and are categorized as "Online Long." In Online Long workshops, participants asynchronously watched a video introducing each section of the worksheet (Supplementary material) and then had 2 weeks to write that section. Participants then met every 2 weeks online, over 14 weeks. In meetings, participants discussed their progress, peer-reviewed an assigned partner's work, asked questions, and discussed challenges with facilitators and each other.

2.4 Statistical modeling

To determine factors that correlate with participants sharing their work, we separated participants into two categories: (1) Published/In-Progress or (2) Not Published. Published/In-Progress includes individuals who either published or have submitted their manuscripts for publication and are actively revising their manuscripts after

1 https://creativecommons.org/licenses/by-nc-sa/4.0/

attending the Writing Studio. Not Published includes individuals who never submitted their manuscripts or submitted their manuscripts and received reviews but did not submit revised manuscripts within a two-year deadline.

We used the package lme4 to conduct binomial linear regression modeling in R (version 4.3.1) to determine which factors contributed to a Writing Studio participant's likelihood of publishing a *CourseSource* article. To account for the nonindependence of the data due to participants attending one of 11 different Writing Studio dates, we used multilevel modeling (Theobald, 2018). In our first model, we explored the influence of predictor variables that included one random effect (Writing Studio start date) and three fixed effects (participant's institution type, Writing Studio modality, and Writing Studio length). We identified the best fit model for the outcome variable (Published/In-Progress or Not Published) using stepwise backward model selection and comparing the estimated goodness of fit of each candidate model using the Akaike information criterion (AIC). The final model was the simplest model with the lowest AIC value (Zuur et al., 2009).

We also explored the influence of career stage on likelihood of publishing. As career stages vary with institution type (e.g., no graduate students or postdocs are typically present at Primarily Undergraduate Institutions), we determined what factors contributed to a Writing Studio participant's likelihood of publishing within doctoral institutions, which included individuals at different career stages (graduate students, postdocs, faculty, and other staff). Among participants coming from doctoral institutions, we included the predictor variables of one random effect (Writing Studio start date) and three fixed effects (participant's career stage, Writing Studio format: in-person vs. online, and Writing Studio length: short vs. long). Using the same backward selection process described above, we identified a best fit model that predicted the likelihood of publishing for a participant affiliated with a doctoral institution.

2.5 Participant surveys

Thirty-five participants in four different Writing Studios (Fall 2021, Summer 2022, Fall 2022, and Spring 2023) completed pre- and post-Writing Studio surveys (Figure 2 and Table 2). On the pre-survey, participants answered questions about why they wanted to participate

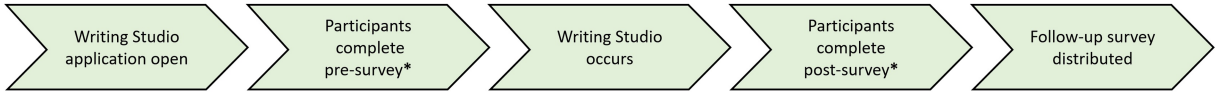

FIGURE 2
Flowchart of Writing Studio implementation and survey data collection. *Not all Writing Studios included a pre- and post-survey (see Table 2).

TABLE 2 Participant counts and survey information for each workshop.

Writing Studio	Participants (*n*)	Pre- and post-survey	Timing of follow-up survey (post-Writing Studio)
In-Person Short			
Summer 2018	38	N/A*	5 years
Summer 2019	29	N/A*	4 years
Summer 2022	10	Pre-survey: $n = 10$ Post-survey: $n = 9$	1 year
Online Short			
Summer 2020, A	17	N/A*	3 years
Summer 2020, B	22	N/A*	3 years
Summer 2021, A	24	N/A*	3 years
Summer 2021, B	12	N/A*	2 years
Summer 2021, C	11	N/A*	2 years
Online Long			
Fall 2021	8	Pre-survey: $n = 8$ Post-survey: $n = 7$	2 years
Fall 2022	6	Pre-survey: $n = 4$ Post-survey: $n = 4$	1 year
Spring 2023	11	Pre-survey: $n = 8$ Post-survey: $n = 7$	3 months
11 total Writing Studios	188 total participants	Pre-survey: $N = 30$ Post-survey: $N = 27$	Follow-up survey: $N = 35$

*No pre- or post-surveys given.

and what goals they hoped to accomplish. On the post-survey, they answered questions about whether their goals were accomplished, and whether the Writing Studio helped or hindered their goals. We also sent a follow-up survey to all 188 Writing Studio participants in the Fall of 2023 (Figure 2), asking participants to reflect on their experience in the Writing Studio. Thirty-five individuals responded to the survey (Table 2), and the first 25 respondents were compensated with a $10.00 Amazon gift card. All survey questions can be found in Supplementary material.

2.6 Qualitative analyses

Answers to free response questions in the pre- and post-survey were analyzed using thematic coding (Creswell and Poth, 2018). SF identified patterns and themes from participant responses and developed a codebook, which was then reviewed, iterated, and agreed upon by JKK. Similarly, answers to free response questions in the follow-up survey were analyzed for themes by ZSH and SF and codes were agreed upon by consensus.

Data were collected under University of Colorado IRB Protocol #22–0259, Cornell University IRB0008360, and University of Maine 2021-01-08.

3 Results

3.1 RQ1: What characteristics predict whether participants share their OERs through a *CourseSource* publication?

To answer this question, we first examined general rates of manuscript submission by Writing Studio participants. Of the 188 total participants, 41.5% submitted a manuscript after attending. Most of these submissions (67%) occurred within the first 6 months and an additional 12% occurred between 6 months and a year. We then categorized participants as either Published/In-Progress (i.e., manuscript published or currently under revision; 38.8%) or Not Published (i.e., did not submit a manuscript or submitted a manuscript but never revised and resubmitted within a two-year deadline; 61.2%) (Table 3). We found that 42.9% of In-Person Short participants, 33.7% of Online Short participants, and 44.0% of Online Long participants published a manuscript.

We then investigated how the rates of manuscript publication varied by different participant characteristics: Writing Studio modality, Writing Studio length, participant institution type, and participant career stage. If a manuscript had co-authors, only those who participated in a Writing Studio were included in calculations. For modality, publication rates were higher for participants who attended the in-person Writing Studios. However, when comparing the long (online only) versus short (both in-person and online) formats, we found that participants from the long format had a higher publication rate. Additionally, publication rates were highest for participants who came from either Doctorate-Granting Universities or Primarily Undergraduate Institutions (PUIs). By position type, graduate students and postdocs had the highest publication rates.

To deduce which factors significantly predicted publication, we determined the best-fitting regression model for all Writing Studio participants. In this model, we retained the fixed effect of institution type and the random effect of Writing Studio start date, the latter accounting for 2% of the total variance in the data. With respect to the influence of institution type on an individual's likelihood of being Published/In-Progress, we found that being at a Community College correlated with a decrease in participants' odds of publishing by

TABLE 3 Publication status of Writing Studio participants, disaggregated by the modality and length of the Writing Studio, institution, and career stage.

	n	Published/In-Progress (%)	Not Published (%)
All participants	188	38.8	61.2
Writing Studio modality			
In-person	77	42.9	57.1
Online	111	36.0	64.0
Writing Studio length			
Long	25	44.0	56.0
Short	163	38.0	62.0
Participant institution type			
Primarily Undergraduate Institution (PUI)	40	45.0	55.0
Doctorate-Granting University	112	42.0	58.0
Master's-Granting University	17	35.3	64.7
Community College	19	10.5	89.5
Participant career stage			
Graduate student	25	52.0	48.0
Postdoc	20	45.0	55.0
Faculty	140	35.7	64.3
Other (e.g., staff, undergraduate)	3	33.3	66.7

73.5%. On the other hand, being at a Master's-Granting University correlated with an increase in these odds by 23.7%, while being at a Doctorate-Granting University or a PUI correlated with an increase in odds by 66.1% and 85.4%, respectively (Supplementary Table S1).

Because doctoral institutions include individuals at the faculty, postdoc, and graduate student career stages, it was possible to examine the influence of different career stages on an individual's likelihood of being in the Published/In-Progress category. Our best fitting model for participants from Doctorate-Granting Universities ($n = 112$) retained only the fixed effect of Writing Studio length. Among participants from Doctorate-Granting Universities, we found that career stage did not have a significant effect, but those attending long-format Writing Studios were 4.1 times more likely to be in the Published/In-Progress category compared to those attending short-format Writing Studios (Supplementary Table S2).

3.2 RQ2: In what ways does participation in a *CourseSource* Writing Studio focused on OER publication help participants achieve their goals?

We examined responses from the pre- and post-Writing Studio surveys (Table 2 and Figure 2) to learn more about the participant experience during the Writing Studio. The demographics for participants who received the pre- and post-surveys are in Supplementary Table S3.

On the pre-survey, both Published/In-Progress and Not Published participants responded similarly to the question "What is your primary goal of attending the *CourseSource* Writing Studio?" Most attendees in both groups had the goal of writing or publishing a manuscript (Figure 3). To a lesser extent, both groups of participants were similarly interested in learning more about writing or publishing a *CourseSource* manuscript as well as receiving feedback.

On the post-survey, when asked about whether their primary goal of attending the Writing Studio was accomplished, nearly all Published/In-Progress participants (~85%) felt they accomplished their goal(s) whereas only 21% of Not Published participants felt they accomplished their goal(s). When participants were asked to elaborate on what supported or hindered them in achieving their goal, Published/In-Progress participants mentioned feeling supported, while Not Published participants reported feeling hindered (Table 4). Published/In-Progress participants reported feeling most supported by the overall structure of the Writing Studio. For example, one participant wrote, "I think that the workshop was structured very well and gave us a very good overview of the steps that we need to take to submit our lesson." Not-Published participants reported feeling most hindered by personal reasons, most frequently citing issues related to time management and conflicting job responsibilities. For example, one participant wrote, "My primary goal was to understand how to compose an article for *CourseSource* and put myself on a schedule to finish an article. The biggest

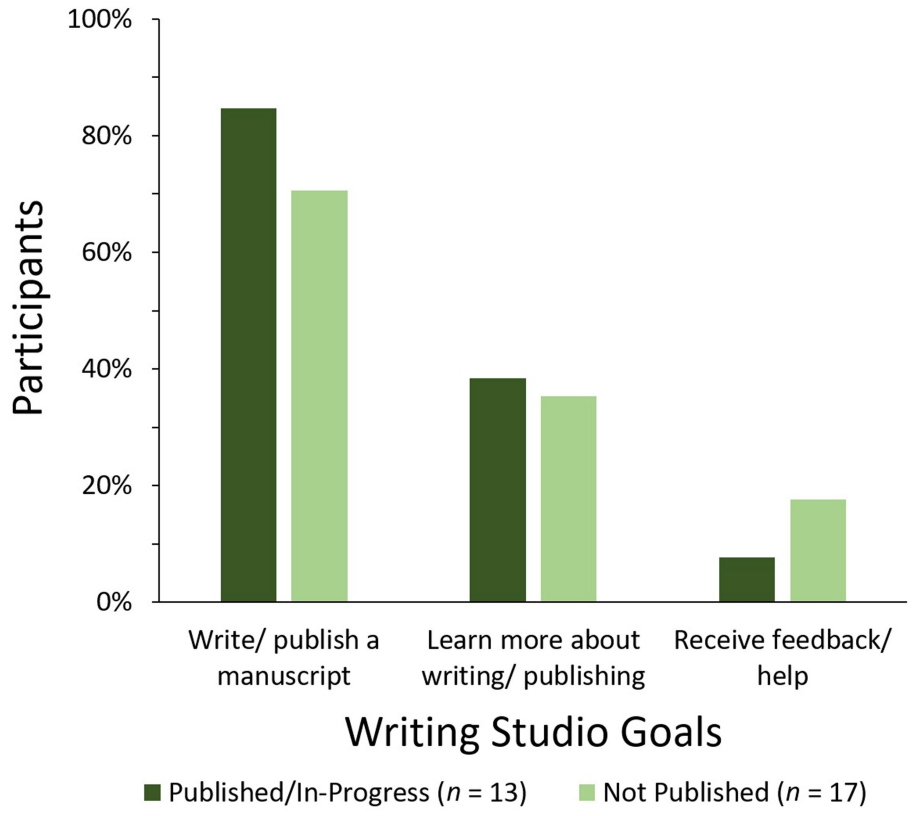

FIGURE 3
Participants' goals from the Writing Studio pre-survey. Thirty of the 35 participants responded to the pre-survey. Among these respondents, 13 are in the Published/In-Progress category and 17 in the Not Published category.

hindrance was being a full-time teaching faculty and some unexpected developments in my department kept pulling my attention away from the studio."

When asked in the post-survey how the Writing Studio could be more useful, participants in both Published/In-Progress and Not Published categories suggested some structural changes to the Writing Studio. These changes included implementing topic-based Writing Studios (e.g., molecular biology lessons), expanding the opportunities to get peer-review from multiple participants and facilitators, having a Writing Studio focused on writing the manuscript followed by a separate workshop focused on editing, and extending the Writing Studio to include more information on manuscript submission.

3.3 RQ3: What long-term supports do participants perceive are necessary to successfully share their work through publication?

On the follow-up survey, several months to years after participation in the Writing Studio, participants were asked to describe any ways that *CourseSource* staff could better assist authors in submitting their article for publication (Figure 4). Many of the Not Published participants reported that attending the workshop helped them realize that their article was not yet ready for publication. Thus, Not Published participants most frequently recommended providing more information before the Writing Studio to help prospective participants better determine their readiness for writing/publishing an article. Other common suggestions included increasing the Writing Studio's length, receiving more feedback from facilitators, and forming pre-submission working groups. In contrast, those in the Published/In-Progress group most frequently stated that they had no suggestions for improvement. A few mentioned that a follow-up meeting on navigating the submission process would have been helpful, as would more reminders about submitting work.

4 Discussion

Within the OER life cycle, sharing poses a notable challenge for instructors. Previous studies showed that between 19 and 28% of instructors in higher education share OERs publicly, such as through formal publication (Admiraal, 2022; Senn et al., 2022). Participating in the Writing Studios yielded a more successful outcome for sharing, with 38.8% of the participants publishing or actively working to publish their work in *CourseSource* (Table 3). However, the low publication rates documented in multiple studies suggest that more work is needed to make publishing OERs more attainable.

Among the various Writing Studio formats, the Online Long workshops had the highest publication rate, suggesting that this mode and length combination may be particularly effective in supporting participants to publish. However, more research will be needed to understand how workshop mode and length impact participants' publication rates. All versions of the Writing Studios focused on lowering the barrier for instructors to participate in the OER life cycle (Figure 1) but offered different benefits. A short-term commitment is likely easier for instructors with busy schedules hoping to get started on writing a manuscript. The longer but lower-intensity commitment of long-term workshops allows for more sustained community interaction and support and more time for working on a manuscript between meetings. By virtue of their repeated, spaced nature, the longer-format workshops also likely offered more reflection

TABLE 4 Supports and hindrances provided by participants in the post-survey.

Participant category	Supported by Writing Studio structure and materials	Supported by peer and facilitator feedback	Hindered by Writing Studio structure and length	Hindered by personal reasons
Published/In-Progress ($n = 8$)	87.5%	37.5%	12.5%	0%
Not Published ($n = 8$)	25%	12.5%	25%	87.5%

Of the 27 participants who answered the post-survey, 16 described supports and hindrances. The percentage of respondents is displayed in the table.

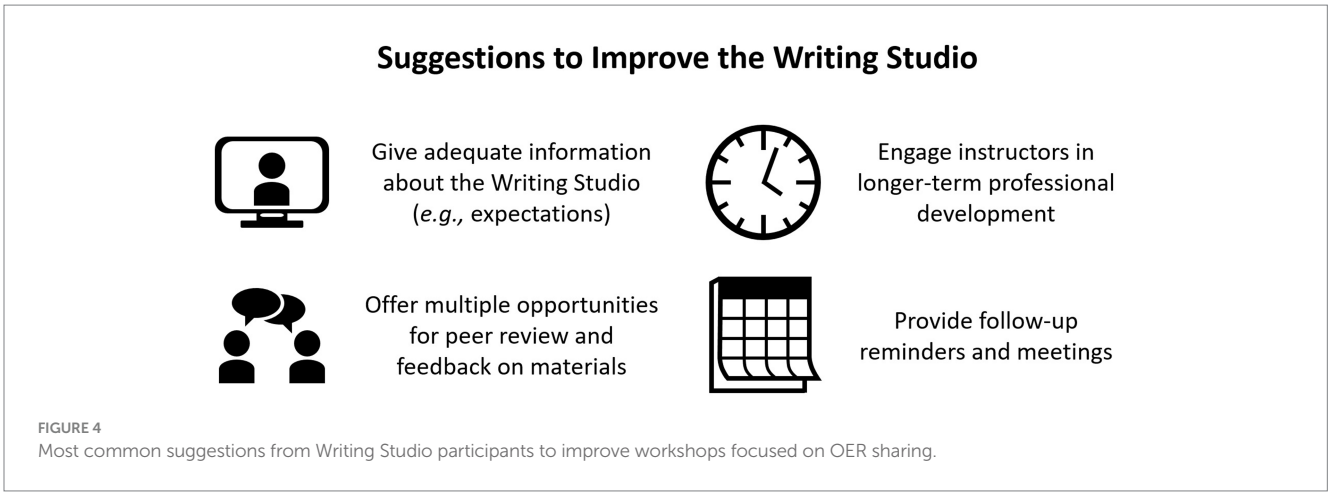

FIGURE 4
Most common suggestions from Writing Studio participants to improve workshops focused on OER sharing.

opportunities and more time to form a network than the short-term workshops (Donovan et al., 2015; Kleinschmit et al., 2023). Thus, having the additional time to reflect, work, and form a community may have positively affected publication outcomes in the Online Long Writing Studio.

Participants from Doctorate-Granting Universities, Master's-Granting Universities, and PUIs were much more likely to publish their work compared to those from Community Colleges (CC) (Table 3). Most participants had the goal of publishing a manuscript, including CC faculty. This finding thus indicates that more support is needed to help CC faculty share their OERs through publication. Having more OERs for CCs is important because they serve a substantial population of undergraduate students: 4.7 million (30% of U.S. undergraduates) enrolled at 2-year institutions in fall 2021 (National Center for Education Statistics, 2023). Additionally, many CC students come from underrepresented backgrounds. For example, 27% of the undergraduate students at public 2-year institutions are Hispanic, which is greater than the percentage of Hispanic students in the overall undergraduate population (22%) (National Center for Education Statistics, 2023). CC faculty have an opportunity to create OERs that will reach a greater diversity of students. In addition, CC faculty create teaching materials tailored for their classrooms that would benefit other 2-year faculty if shared. This highlights a valuable opportunity for the OER community to better recruit and support CC faculty in the OER sharing process.

Professional development opportunities, such as the Writing Studio, are often targeted at faculty, because they are already in permanent teaching positions. However, we found the highest number of Published/In-Progress individuals were at the graduate student and postdoc career stage (Table 3). Encouraging graduate students and postdocs to contribute OERs serves several purposes including providing new educational ideas to the community and helping early-career academics build their CVs for future positions (Smith, 2018). In addition, institutions can create courses that help graduate students and postdocs create, implement, and share OERs. For example, at Cornell University, a semester-long graduate course focuses on selecting a biology topic, using backward design to develop a lesson (Wiggins and McTighe, 2005), teaching the lesson in a classroom, collecting information from students, and publishing a *CourseSource* article (Genova et al., 2020; Wollmuth et al., 2022). Graduate students who participate in this process can highlight their teaching experience with a peer-reviewed publication. Future OER workshops could explicitly encourage graduate students and postdocs to participate and stress the value such publications can have for early career academics.

4.1 Future improvements to OER professional development

This work has provided valuable insights into how workshops focused on OER sharing can be enhanced. Both the Published/In-Progress and Not Published participants acknowledged feeling supported during the workshop and benefited from the peer-review partner system and workshop materials. However, participants mentioned that more can be done to improve the usefulness of the Writing Studio, providing ideas that are applicable across professional development programs (Figure 4). Not Published participants overwhelmingly reported needing more time for writing and more feedback from peers. To facilitate more opportunities for feedback, some participants suggested increasing the size of the peer-review groups to more than two. Several studies on undergraduate biology student peer groups have shown that all individuals in heterogeneous groups, comprising members with varying levels of experience both outperform and have better attitudes than individuals in homogeneous groups (Donovan et al., 2018). Instructors may respond similarly to being part of a larger heterogeneous group when receiving feedback during the process of writing their *CourseSource* article. If groups consist of instructors with varied experience in writing and publishing OERs, participants may ultimately receive feedback that empowers them to write and submit their OERs. In addition, it could be helpful to share data from previous workshops to better inform future participants. For example, our data show that most participants submitted their manuscript within a year of completing the Writing Studio. During this crucial period, workshop facilitators should establish additional support mechanisms, such as check-in meetings, regular email reminders, and assistance with editing.

The current Writing Studio model falls short of effectively engaging CC participants. There are likely many structural barriers that are preventing CC faculty from enrolling in the Writing Studio (10.1% of total participants) or reaching the publication stage after the workshop (10.5% of CC participants). These faculty are constrained by time, often due to heavy teaching loads and service requirements (Schinske et al., 2017; Creech et al., 2022). Additionally, CC faculty have less access to administrative support (e.g., IRB offices), information and technology infrastructure (e.g., journal publications), and resources/funding (Schinske et al., 2017; Creech et al., 2022). Furthermore, there are usually few formal incentives or rewards for publishing by CC faculty (Schinske et al., 2017). Thus, to more effectively engage CC faculty in OER sharing, professional development programs need to provide more support strategies specifically targeted for their needs, such as expanding peer feedback in the form of mentorship. CC faculty may have less experience with biology education research and limited access to mentors (Schinske et al., 2017). By pairing a CC faculty member with someone more experienced in biology education research and OER sharing, community college faculty may receive more support in developing, writing, and publishing OERs (Sato et al., 2023).

Since journals can serve as an avenue for OER sharing, *CourseSource* has the opportunity to provide support to CC faculty interested in developing and sharing OERs. *CourseSource* follows many practices that theoretically support all potential authors (e.g., extensive author instructions, page charge waivers, helping authors refine their submissions, and open-access articles; Schinske et al., 2017). Additionally, CC faculty serve as reviewers and on the *CourseSource* editorial board (Schinske et al., 2017). However, better engagement with CC faculty is still needed. Schinske et al. (2017) describe several strategies journals can use to broaden engagement and participation. *CourseSource* could host networking events specifically for CC faculty, hold online webinars on the publishing process, and provide dedicated spaces to highlight and recognize OERs for/by CC faculty. In addition, *CourseSource* could create a feature issue for CC faculty (Alvares et al., 2022). Future work could survey contributors from CC to determine what types of information and resources other CC authors would find useful.

4.2 Limitations

The goal of the Writing Studios was to provide resources, supports, and structure to help all participants write and submit an OER to *CourseSource*. While the workshop successfully resulted in increased OER sharing, the participant pool was biased toward individuals who hail from Doctoral-Granting Universities where there is pressure to publish. These participants may have been more motivated to participate and share their OERs since *CourseSource* publications can enhance CVs for hiring, promotion, and tenure. Thus, the overall publication rate may have been enhanced by their majority participation in the workshop. Future workshops could focus on recruiting a more diverse group of participants from PUIs and community colleges to mitigate bias and more accurately reveal how well the workshops support OER sharing.

In addition, much of the data collected in this work came from self-reports on surveys. Since identifying information was collected, participants may have answered in a socially desirable manner by over-reporting positive experiences and achievements (Klassen et al., 1975). Additionally, the follow-up survey was administered months to years after participation, which may have resulted in participants not accurately remembering or reporting past events or experiences (Raphael, 1987). Conducting more frequent follow-ups or implementing a longitudinal study design could provide a clearer understanding of the long-term impact of the Writing Studio on OER sharing behavior. As fewer than one fifth of participants responded to the follow-up survey, we may have received an incomplete picture of the participants' experiences and the effectiveness of different components of the Writing Studio. To gain a more comprehensive understanding of participants' experiences, future studies could incorporate additional sources of data, such as interviews or observational data.

Lastly, for the purposes of our study, we chose to report OER sharing in terms of publication rates in *CourseSource*. It is possible that Writing Studio participants are sharing their resources informally, for instance, with colleagues or via online platforms (e.g., QUBES). However, it is unlikely that participants would participate in the *CourseSource* Writing Studio and then formally publish their OER in a different journal. Only a few other platforms (e.g., Journal of Microbiology and Biology Education) offer formal peer-review and publication of undergraduate biology OERs, and participants worked within a specific template and guidelines to create their lessons.

5 Conclusions and future work

The Writing Studio facilitated an increased rate of OER sharing than previously reported in the literature, demonstrating that targeted professional development initiatives can effectively support educators in developing, refining, and submitting OERs for publication. However, factors such as institution type and career stage significantly influence the likelihood of participants sharing their OERs through publication. Many participants mentioned facing common challenges, including time constraints and conflicting responsibilities, which hindered their ability to engage in OER sharing. Addressing these challenges is crucial for increasing the sharing of OERs by those from underrepresented institutions.

In addition, conducting follow-up studies with participants who did not publish their OERs may help to gain a better understanding of the challenges they faced and identify strategies to better support them in the publication process. For example, it would be useful to examine participants' motivation for participating in OER sharing and how to best support them (Creech et al., 2022). Exploring ways to increase engagement of faculty from diverse institution types could also help address the disparities in OER sharing seen in our study. Investigating the effectiveness of additional support mechanisms, such as mentorship programs, expanded peer feedback, or dedicated resources for CC faculty, could help improve the engagement and publication rate of participants from different institutions.

To enhance the engagement of participants who are less likely to submit their OERs, additional supports and resources are needed. Thus, future work should explore what mechanisms and workshop components are most effective in supporting participants, and whether CC instructors have unique needs. Helping instructors overcome barriers to OER sharing will help broaden and diversify the available resources by increasing the number of OERs designed for audiences outside Doctorate-Granting Universities. Additionally, encouraging the participation of graduate students and postdocs in OER writing workshops and communities can further expand and diversify OERs while also providing meaningful professional development. Finally, understanding the sustained effects of the Writing Studio over time could provide deeper insights into its effectiveness. For example, one could investigate how the long-term impacts of participants' experiences in the Writing Studio influence their professional development, career trajectories, teaching practices, and OER sharing behaviors.

Overall, this work sheds light on the various challenges associated with OER sharing among educators and highlights the importance of fostering supportive environments and implementing targeted strategies to promote equity in OER sharing.

Data availability statement

De-identified raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the University of Colorado IRB Protocol #22-0259, Cornell University IRB0008360, and University of Maine 2021-01-08. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

SF: Conceptualization, Formal Analysis, Visualization, Writing – original draft, Writing – review & editing. ZSH: Data curation, Writing – original draft, Writing – review & editing. MR: Data curation, Writing – original draft, Writing – review & editing. KT:

Formal analysis, Visualization, Writing – original draft, Writing – review & editing. EV: Data curation, Writing – original draft, Writing – review & editing. MKS: Conceptualization, Funding acquisition, Writing – original draft, Writing – review & editing. JKK: Conceptualization, Funding acquisition, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1422383/full#supplementary-material

References

Admiraal, W. (2022). A typology of educators using open educational resources for teaching. *Int. J. Stu. Educ.* 4, 1–23. doi: 10.46328/ijonse.60

Alvares, S. M., Gonzalez, B., Hewlett, J. A., Kurushima, J. D., McFarland, J. L., Schinske, J. N., et al. (2022). Centering the experiences of community college students and faculty in biology education research. *CBE—Life Sci. Educ.* 21:ed1. doi: 10.1187/cbe.22-07-0145

Bateman, P., Lane, A., and Moon, R. (2012). "An emerging typology for analysing OER initiatives" in Cambridge 2012: Innovation and Impact – Openly Collaborating to Enhance Education, a Joint Meeting of OER12 and OpenCourseWare Consortium Global 2012, 16–18 April 2012 (Cambridge). Available at: https://oro.open.ac.uk/33243/

Beaven, T. (2018). 'Dark reuse': an empirical study of teachers' OER engagement. *Open Praxis* 10, 377–391. doi: 10.5944/openpraxis.10.4.889

Caudill, J. (2011). Using OpenCourseWare to enhance on-campus educational programs. In Proceedings of TCC 2011 43–47. TCC Hawaii. Available at: https://www.learntechlib.org/p/43742/ (Accessed August 2, 2023).

Clements, K. I., and Pawlowski, J. M. (2011). User-oriented quality for OER: understanding teachers' views on re-use, quality, and trust. *J. Comput. Assist. Learn.* 28, 4–14. doi: 10.1111/j.1365-2729.2011.00450.x

CourseSource. (2024). Home page. Available at: https://qubeshub.org/community/groups/coursesource (Accessed February 7, 2024).

Creech, C., Just, J., Hammarlund, S., Rolle, C. E., Gonsar, N. Y., Olson, A., et al. (2022). Evaluating the representation of community colleges in biology education research publications following a call to action. *CBE—Life Sci. Educ.* 21:ar67. doi: 10.1187/cbe.21-09-0249

Creswell, J. W., and Poth, C. N. (2018). Qualitative inquiry and research design: choosing among five approaches. *4th* Edn. Thousand Oaks, CA: SAGE Publications.

Donovan, D. A., Connell, G. L., and Grunspan, D. Z. (2018). Student learning outcomes and attitudes using three methods of group formation in a nonmajors biology class. *CBE—Life Sci. Educ.* 17:ar60. doi: 10.1187/cbe.17-12-0283

Donovan, S., Eaton, C. D., Gower, S. T., Jenkins, K. P., LaMar, M. D., Poli, D., et al. (2015). QUBES: a community focused on supporting teaching and learning in quantitative biology. *Lett. Biomathemat.* 2, 46–55. doi: 10.30707/LiB2.1Donovan

Eddy, S. L., and Hogan, K. A. (2014). Getting under the hood: how and for whom does increasing course structure work? *CBE—Life Sci. Educ.* 13, 453–468. doi: 10.1187/cbe.14-03-0050

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., et al. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proc. Natl. Acad. Sci. U.S.A.* 111, 8410–8415. doi: 10.1073/pnas.1319030111

Genova, L. A., Johnson, B. B., Castelli, F. R., Arcila Hernández, L. M., Chang van Oordt, D. A., Demery, A.-J., et al. (2020). What is speciation, how does it occur, and why is it important for conservation? *CourseSource*. 7, 1–19. doi: 10.24918/cs.2020.28

Griffiths, R., Gardner, S., Lundh, P., Shear, L., Ball, A., Mislevy, J., et al. (2018). Participant experiences and financial impacts: findings from year 2 of achieving the dream's OER degree initiative. Menlo Park, CA: SRI International.

Gurell, S. (2008). Open educational resources handbook 1.0 for educators: Center for Open and Sustainable Learning. Available at: http://www.lulu.com/shop/seth-gurell/open-educationalresources-handbook-for-educators-version-10/ebook/product-17400463.html

Hassler, B., Hennessy, S., Knight, S., and Connolly, T. (2014). Developing an open resource bank for interactive teaching of STEM: perspectives of school teachers and teacher educators. *J. Interact. Media Educ.* 1–24. doi: 10.5334/2014-09

Henderson, C., Beach, A., and Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: an analytic review of the literature. *J. Res. Sci. Teach.* 48, 952–984. doi: 10.1002/tea.20439

Hilton, J. L. III, and Wiley, D. (2011). Open access textbooks and financial sustainability: a case study on flat world knowledge. *Int. Rev. Res. Open Distrib. Learn.* 12, 18–26. doi: 10.19173/irrodl.v12i5.960

Hylén, J. (2006). Open educational resources: opportunities and challenges. Paper presented at the Open Education 2006: Community, Culture, and Content. Logan, UT: : Center for Open and Sustainable Learning (COSL).

Klassen, D., Hornstra, R. K., and Anderson, P. B. (1975). Influence of social desirability on symptom and mood reporting in a community survey. *J. Consult. Clin. Psychol.* 43, 448–452. doi: 10.1037/h0076863

Kleinschmit, A. J., Rosenwald, A., Ryder, E. F., Donovan, S., Murdoch, B., Grandgenett, N. F., et al. (2023). Accelerating STEM education reform: linked communities of practice promote creation of open educational resources and sustainable professional development. *Int. J. STEM Educ.* 10:16. doi: 10.1186/s40594-023-00405-y

Lane, A., and McAndrew, P. (2010). Are open educational resources systematic or systemic change agents for teaching practice? *Br. J. Educ. Technol.* 41, 952–962. doi: 10.1111/j.1467-8535.2010.01119.x

Lynd-Balta, E., Erklenz-Watts, M., Freeman, C., and Westbay, T. D. (2006). Professional development using an interdisciplinary learning circle. *J. Coll. Sci. Teach.* 35, 18–24.

National Center for Education Statistics. (2023). Characteristics of postsecondary students: condition of education. U.S. Department of Education, Institute of Education Sciences. Available at: https://nces.ed.gov/programs/coe/indicator/csb (Accessed February 10, 2024).

Raphael, K. (1987). Recall bias: a proposal for assessment and control. *Int. J. Epidemiol.* 16, 167–170. doi: 10.1093/ije/16.2.167

Sato, B., Callis-Duehl, K., Lo, S., and Giblin, T. (2023). BEIC - creation of the biology educator/researcher cross-segment collective (RCN-UBE introduction). RCN-UBE Community, QUBES Educational Resources. doi: 10.25334/89X3-S119

Schinske, J. N., Balke, V. L., Bangera, M. G., Bonney, K. M., Brownell, S. E., Carter, R. S., et al. (2017). Broadening participation in biology education research: engaging community college students and faculty. *CBE—Life Sci. Educ.* 16:mr1. doi: 10.1187/cbe.16-10-0289

Senn, L. G., Heim, A. B., Vinson, E., and Smith, M. K. (2022). How do undergraduate biology instructors engage with the open educational resource life cycle? *Front. Educ.* 7:835764. doi: 10.3389/feduc.2022.835764

Smith, M. K. (2018). Publishing activities improves undergraduate biology education. *FEMS Microbiol. Lett.* 365:fny099. doi: 10.1093/femsle/fny099

Theobald, E. (2018). Students are rarely independent: when, why, and how to use random effects in discipline-based education research. *CBE—Life Sci. Educ.* 17:rm2. doi: 10.1187/cbe.17-12-0280

Theobald, E. J., Hill, M. J., Tran, E., Agrawal, S., Arroyo, E. N., Behling, S., et al. (2020). Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. *Proc. Natl. Acad. Sci. U.S.A.* 117, 6476–6483. doi: 10.1073/pnas.1916903117

UNESCO. (2019). Recommendation on open educational resources. UNESCO General Conference, 40th. UNESCO. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000370936

Van Acker, F., Vermeulen, M., Kreijns, K., Lutgerink, J., and van Buuren, H. (2014). The role of knowledge sharing self-efficacy in sharing open educational resources. *Comput. Hum. Behav.* 39, 136–144. doi: 10.1016/j.chb.2014.07.006

Wenger, E. (2011). Communities of practice: a brief introduction. STEP Leadership Workshop, University of Oregon, October, 2011. Available at: https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/11736/A%20brief%20introduction%20to%20CoP.pdf (Accessed December 20, 2023).

Wiggins, G., and McTighe, J. (2005). Understanding by design expanded. *2nd* Edn. ASCD: Alexandria, VA.

Wiley, D. (2007). Open education license draft: iterating toward openness (blog post). Available at: http://opencontent.org/blog/archives/355

Wiley, D. (2014). The access compromise and the 5th R: iterating toward openness (blog post). Available at: http://opencontent.org/blog/archives/3221

Windle, R., Wharrad, H., McCormick, D., Laverty, H., and Taylor, M. (2010). Sharing and reuse in OER: experiences gained from open reusable learning objects in health. *J. Interact. Media Educ.* 1–18. doi: 10.5334/2010-4

Wollmuth, E. M., Sless, T. J. L., Airey, M. E., France, E. D., Stump, E. M., Sundstrom, M. A., et al. (2022). Is Earth currently undergoing a sixth mass extinction? *CourseSource.* 9, 1–10. doi: 10.24918/cs.2022.19

Zuur, A. F., Ieno, E. N., Walker, N. J., Saveliev, A. A., and Smith, G. M. (2009). Mixed effects models and extensions in ecology with R. New York, NY: Springer.