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COMMENT

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# Open for whom? The need to define open science for science education

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Open science has become a part of the discourse around educational research (van der Zee & Reich, 2018), including in science education. As a case in point, Sadler and Mensah (2020) observed in the pages of the *Journal of Research in Science Teaching (JRST)* that while "open science is in its early stages and has yet to impact science education research in significant ways," it "will influence the science education publishing world including *JRST*" (p. 150). Reflecting on the potential of open science to our field, Sadler and Mensah wrote that *JRST* "needs to become a leading voice in the field's response to open science." (p. 151).

We agree that open science will influence science education publishing and *JRST*. In this commentary, we argue that the critical task ahead for science education researchers is to redefine what constitutes open science for science education. In so doing, we argue that we can bolster both science education and open science at the same time.

## 1 | THE KEY PROBLEM: THERE IS NOT ONE OPEN SCIENCE

As it is currently defined within other educational research subfields, open science has been distinguished by calls to make published research more accessible and to improve the reproducibility of research (van der Zee & Reich, 2018). While these are critical, a narrow focus on these practices runs the risk of an open science movement that addresses only a subset of the concerns of science education researchers. At the same time, a narrow focus might set aside concerns about pressing issues, such as equity, community engagement, practitioner access to

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resources, and expanding the types of resources (like curricula) we create. And, finally, if open science does not connect with the issues and practices that are central to the work of science education researchers, its uptake, sustainability, and impacts may be limited.

This article aims to advocate for open science while also questioning how we go about making open science practices the norm in science education. At the center of our case is the broader sociocultural context for our work: As the science education research community is grappling with issues of equity and social justice, we are presented with an opportunity to reimagine how we want open science to be instantiated in our discipline to address the needs of the broader community based on the assets and barriers science educators face.

## 2 | THE NEED TO DEFINE WHAT CONSTITUTES OPEN SCIENCE

What we consider to be open science matters because these practices may be elevated in prominence and value as open science is taken up in the science education research community (Sadler & Mensah, 2020). For example, preregistering one's method for a study (before collecting and analyzing any data; see Center for Open Science, 2021) has become a key way that open science has been explored by educational researchers—see Gehlbach and Robinson (2021) and the special issue on educational psychology in the open science era. The prominent role of preregistration reflects the values of educational psychologists and those of many other behavioral and health sciences scholars. In this context, reproducibility (of analyses) and replicability (of findings) are key, though scholars have pointed out that replicability may not be a universal standard that scientific research from all fields must aspire to meet (Guttinger, 2020).

We think that reproducibility and replicability have a role in our field but that other, additional practices can be identified by reflecting on the values of science education researchers—such as the value of creating and sharing curricular resources. To elaborate, at present, many in the science education community are currently involved in creating and sharing curricular materials (OpenSciEd, 2021) and associated tools (Ambitious Science Teaching, 2021). In the above-referenced special issue on educational psychology in the open science era, Fleming et al. (2021) described how scholars can use digital tools to share open data and code, materials, and publications. They describe a variety of open materials that may be shared, including (but, the authors are careful to note, not limited to):

> intervention materials and implementation procedures, researcher-created dependent measures, fidelity and treatment integrity checklists, survey instruments, data collection forms, training procedures and manuals, interview or observational protocols, positionality or reflexivity statements, data integration methods, and deductive or inductive codebooks" (p. 114).

Curricular materials and tools for educators (and researchers) are used by science education researchers in a manner that compares to how educational psychologists use—for example—training procedures and manuals. Yet, we are unaware of any definitions of open science that recognize creating curricular materials. We think this can and should change.

In addition to addressing preregistration practices, considering the values that science education researchers bring to their work could suggest modifications to how we carry out open science in our field. How *open access* is defined could be broadened to include an important goal

shared by many science education researchers of connecting our work with the wider science education community—including practitioner and policymaking communities.

As an illustration, consider the notion that "greater access to education research will provide greater transparency for a wider audience of researchers, policymakers, and educators" (van der Zee & Reich, 2018, pp. 3–4). This is a sound claim in our view; however, a focus exclusively on open access may be too narrow in light of the notion that long-term, mutually sustaining partnerships should focus on addressing problems of practice in science education (Penuel, 2017). In this way, how the science education community defines *accessibility* can be broader than just open access; it should also include how we plan our research in collaboration with teachers, and how we deliberately share our research findings with teachers—and parents, administrators, and policymakers. For example, at the same time that it can become an open science-related norm for science education researchers to post preprints[1] of articles otherwise behind paywalls, it can also become a norm for researchers to share the implications of our work for science teachers (in journals, blog posts, or even via social media). In this way, asking the question of what counts as open science can lead us to define open science in a way that helps us to achieve the ends we value.

We have described how open science practices can be modified or augmented by defining open science around what we as science education researchers value. But, the values of those defining open science are not necessarily universal, and open science begins with questioning who has the power to define and advance open science. We discuss this consideration next.

## 3 | WHO DEFINES OPEN SCIENCE

While open science does allow for broader sharing and uptake of research findings, the overhead associated with engaging in open science—such as the additional time that open science practices like anonymizing and sharing data and preregistering require—is often overlooked by those who are currently best served within the existing system. Many open science practices require funding and/or support from graduate students or support staff that are not available to all science education researchers. In this way, an open science imperative can represent an impossible barrier to those most at risk in our communities. Thus, in addition to interrogating what counts in science education and open science, part of defining open science to meet community goals involves considering who has the opportunities to participate in it. This is essential because science is conducted by people who exist within a social structure that reflects Eurocentric, Westernized, and colonized perspectives and norms that impact science (Leonardo & Broderick, 2011)—and, we argue, open science.

Adopting open science to address the problems that are unique to one approach to research does not explicitly consider the impacts of power within science education (Ireland et al., 2018), which may limit who participates in open science. Consider an example of a Black, female, junior faculty member in a tenure-track science education position at a research-intensive institution. Her racialized and gendered identity as a Black woman posits her within a double bind (Ong et al., 2011). Women of color are underrepresented among faculty across the nation (Casad et al., 2021; Liu et al., 2019; Towns, 2010). Additionally, she is likely to engage in invisible labor such as mentoring (Reid, 2021) and serving in volunteer roles within her department and college (Harley, 2008). Due to these added service efforts, her research capacity is limited (Corneille et al., 2019). As she considers participating in open science, she now has to examine the additional time required to anonymize data, share data, and preregistering. In the same

ways, her identities situated her within STEM education, those identities impact how she participates in open science as a researcher. Continuing open science practices as they are presently defined may affect the progress of faculty members like the one we mentioned on her goal toward tenure and greater job security. More broadly, by not asking who is defining open science and who benefits from doing open science, the adoption of open science may be constrained in its potential impact.

For an open science to better serve the needs of all science education researchers, we must attend to the experiences of varied populations using intersectional lenses within the context of open science. An intersectional perspective highlights that the question of who defines open science in science education does not simply involve inviting scholars who represent different identities within science education but includes critically questioning how the make-up of those defining open science may reflect multiple forms of privilege (or disadvantage). We are suggesting the applications of a critical lens for "liberatory or transformative response to racial, gender, and class oppression" (Solorzano & Yosso, 2001, p. 8) while amplifying experiential knowledge (Brayboy, 2005). Therefore, just as how framings such as culturally relevant (Ladson-Billings, 1995) and sustaining (Paris & Alim, 2014) pedagogies have led to the incorporation of students' culture and social experiences within science education (Adjapong et al., 2016) the same can and should be done when defining open science. Such applications of frameworks include but are not limited to the intentional inclusions of culture beyond the normalization of Whiteness within science education (Mensah & Jackson, 2018; Sammel, 2009) and consideration of racialized and gendered experiences (Nasir, 2011) in science education.

An expansive vision for open science includes diversifying who defines open science and beginning to envision the ways open science can reorder power dynamics within science. The growth of open science should come through the careful consideration of cultural and intersectional perspectives as they are also being considered in science education. We suggest asset-based framings of culture and identity (Bang & Medin, 2010) when considering sharing and accessing data as a part of an open science process. The possibilities for how these and other intentional inclusions can manifest are expansive; we can discover new forms of open science practices that are more culturally relevant and sustaining to those with whom we work. At the same time, if open science reforms are *not* explicitly informed by the concerns of the broader science education community, then we run the risk of perpetuating the marginalization of members of the science education community.

## 4 | ENVISIONING AN OPEN SCIENCE FOR SCIENCE EDUCATION

In this commentary, we expanded on Sadler and Mensah's (2020) enthusiasm for open science and their simultaneous caution about us blindly adopting open science as defined by scholars working in other domains. We wholeheartedly agree that open science is important, valuable, and should be an increasingly integral part of science education research but argue that science education researchers should define open science practices for the science education community. Moreover, we must critically consider has opportunities to participate in and benefit from open science; doing so suggests that it is imperative to.

In conclusion, open science constitutes a set of practices that can have a positive impact on science education, but that requires the buy-in and input of the science education community—not just the adoption and implicit definition of open science by a subset of science

education researchers. In doing so, our field's adoption of open science can serve as an example for other fields of how to adopt open science while not losing sight of the problems and goals that drive our work as science education researchers.

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## ENDNOTE

[1] See Bourne et al. (2017) for practical guidance on how to do this.

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