Open Science in the Field of Emotional and Behavioral Disorders

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Abstract

Students with emotional and behavioral disorders (EBD) present some of the greatest challenges faced by educators, and experience some of the most problematic outcomes. To increase the likelihood that students with EBD will be successful in school and in life, practitioners should implement effective interventions. Trustworthy research is the primary means to identify effective practices. Open science can be used to help verify research findings as trustworthy, as well as improve their accessibility. In this article, we discuss the open science movement and describe five open-science practices (i.e., preregistration, Registered Reports, open data and materials, open access and preprints, and open review) that may help increase the trustworthiness, efficiency, and impact of EBD research. We argue that the implementation of these practices may increase the field's capacity to identify and verify truly effective practices, and facilitate broad accessibility of the research for all stakeholders; thereby improving policies and instructional practice for students with EBD.

Key words: open science, preregistration, open data, open access, emotional and behavioral disorders

Open Science in the Field of Emotional and Behavioral Disorders

Individuals with emotional and behavioral disorders (EBD) present some of the greatest challenges for educators, both in general and special education settings (Kauffman & Landrum, 2018). Although analyses of national data from the United States indicate that these disorders are associated with many comorbid issues such as poverty, lack of neighborhood safety, and inadequate access to health care, poor parental mental health (Bitsko et al., 2016), for special educators it is probably less important to know with what these problems are correlated than to know what to do to address the problems of students with EBD in schools. Professional educators should use highly effective instructional practices, and eschew ineffective interventions, especially for students with EBD and other at-risk populations. Scholars have recommended that scientific research is the best way to discern the effectiveness of instructional practices for students with EBD (Zaheer et al., 2019). Concerns about contemporary science, however, have raised questions about the credibility of research findings. Research underlying the so-called replication crisis, for example, has revealed that study findings often fail to replicate (e.g., Camerer et al., 2018; R. Klein et al., 2018; Open Science Collaboration, 2015). Educators should predicate their practice on research, but not when there are serious questions about the replicability and trustworthiness of research evidence. The problem is analogous to the famous discussion between Soviet Premier Gorbachev and US President Reagan in the 1980s in which they agreed to follow a Russian proverb: Trust but verify. When research has been verified, then it can be trusted.

Open science provides a means for verifying research findings, as well as improving other aspects of the research enterprise. Open science refers to a compendium of principles and practices aimed at making science more trustworthy, efficient, and impactful by emphasizing

openness and transparency throughout the research process (Cook, Lloyd, Mellor, Nosek, & Therrien, 2018). Although open science is changing how research is being conducted in fields such as psychology and medicine, it is just beginning to be used by researchers in special education and the EBD field. Our aim in this paper is to provide context and justification for open science, and discuss how open science can and is being applied in the EBD field. We provide a brief overview of open science and its rationale, and then describe five prominent open-science practices: (a) preregistration, (b) Registered Reports, (c) open data and materials, (c) open access and preprints, and (d) open review. For each open practice, we briefly describe what that practice entails and how it works, its primary benefits and the main concerns about it, and examples and special considerations related to the EBD field. We conclude with a brief discussion of changing the culture among EBD researchers to promote open science as a means to verify research and improve practice.

What Is Open Science and Why Is It Important?

Open science encompasses different approaches for opening the process of knowledge creation and dissemination. Masuzzo and Martens (2017) posed four pillars of open science: open data, open code, open data, and open review. Alternatively, Fecher and Friesike (2014) described five schools of open science: democratic (open access to research), infrastructure (open research tools and applications), measurement (alternative metrics for scientific impact), pragmatic (open research data and materials), and public (making science more accessible). Cutting across these pillars and schools, Nielsen (2011) informally suggested that open science is the idea that all scientific knowledge should be shared as early as possible. By making the research process open and shared, open science aims to strengthen the validity, efficiency, and impact of research.

Researchers are reinforced primarily for publishing their studies in journals with high impact factors and obtaining grants (Carroll, 2018) rather than for conducting sound research. Accordingly, Nosek, Spies, and Motyl (2012) suggested that researchers are incentivized for “getting it published” rather than “getting it right” (p. 615). To get articles published in highly competitive journals, researchers may feel compelled to generate “perfect-looking results” (Giner-Sorolla, 2012, p. 562; i.e., novel and statistically significant findings) by engaging in questionable research practices. Indeed, researchers report commonly engaging in practices such as p-hacking (e.g., reanalyzing data until obtaining desired findings, determining when to stop collecting data depending on statistical significance of findings), hypothesizing after results are known (HARKing; i.e., treating exploratory findings as if they were predicted *a priori*), cherry-picking (i.e., selectively reporting positive findings), and publication bias (i.e., not publishing studies with negative findings; e.g., John, Loewenstein, & Prelec, 2012).

Perhaps because original researchers hoped to generate perfect-looking results, possibly by employing questionable practices, independent researchers’ direct replication efforts have too often failed to reproduce the positive results reported in the original studies (Camerer et al., 2018; R. Klein et al., 2018; Open Science Collaboration, 2015). For example, when the Open Science Collaboration directly replicated 100 studies in psychology, whereas 97 of the original studies reported statistically significant findings, only 36 of the replications reached statistical significance. Given the frequency of questionable research practices and publication bias (e.g., John et al., 2012), as well as the general scarcity of replication studies (Makel & Plucker, 2014), the low rate of reproducing positive findings (e.g., Open Science Collaborative, 2015) is not surprising. Thus, the scientific literature probably contains many undiscovered false-positive findings and may, accordingly, exaggerate the effects of many interventions (Ioannidis, 2012;

Munafo et al., 2017).

Although meta-research examining the special education and EBD research bases is limited, preliminary evidence suggests that it is not immune to many of the aforementioned issues. For example, reviews of the special education literature indicate studies with null findings are less likely to be published than those with positive findings (Gage, Cook, & Reichow, 2017; Therrien & Cook, 2018), which reflects publication bias. Publication bias and scarcity of studies with null findings also appear to exist in the single-case design (SCD) research base (Kittleman, Gion, Horner, Levin, & Kratochwill, 2018; Sham & Smith, 2014), which commonly informs policy and practice for students with EBD. In fact, Shadish, Zelinsky, Vevea, and Kratochwill (2016) found that a “non-trivial minority” (p. 656) of SCD researchers (4–15%, depending on the condition) reported they would drop one or two cases with small effect sizes before submitting a study for publication. Moreover, reviews of the special education literature suggest that direct replication studies are exceedingly rare (Makel et al., 2016), rendering many research findings unverified.

Open science practices may provide mechanisms for verifying research findings and addressing questionable research practices in EBD research, as well addressing related issues in contemporary research (e.g., research being kept behind a paywall and inaccessible to many stakeholders, data and materials seldom being shared, limitations of peer review). In the next section, we describe five specific open science practices and how they have been or may be applied in EBD research.

Open Science in Practice

Preregistration

What is preregistration? Preregistration seeks to reduce researcher flexibility when

collecting, analyzing, and reporting confirmatory research by researchers publicly registering their methods before conducting the study (Nosek, Ebersole, DeHaven, & Mellor, 2018). By publicly registering study plans, any changes to hypotheses (e.g., HARKing), statistical analyses (e.g., p-hacking), or reporting of findings (e.g., selective reporting) to obtain desired findings are readily detectable. Preregistrations typically are posted on online, accessible, and searchable registries. Registries are commonly free, can be general (e.g., on the Open Science Framework, <https://osf.io>) or domain-specific (e.g., the Registry of Efficacy and Effectiveness Studies, <https://www.sreereg.org>, is designed for educational studies), and typically provide one or more preregistration templates. Preregistrations are time stamped, uneditable, assigned a permanent and unique identifier, and searchable. Although preregistration formats vary, they typically include specific research questions and detailed plans of study methods. Preregistrations can be used by editors and reviewers, research consumers, and researchers themselves to verify that a study was conducted as planned. Resources for preregistration are available on the Open Science Framework at <https://cos.io/prereg/>.

Benefits and concerns. The primary benefit of preregistration is reducing researchers' flexibility when conducting studies, analyzing data, and reporting results. Traditionally, researchers may alter research questions, statistical analyses, and reporting, but then report the study as if research questions and methods were determined a priori and reported faithfully (Simmons, Nelson, & Simonsohn, 2011). By publicly preregistering study plans, any changes and exploratory methods are easily detected and must be justified, thereby reducing these questionable research practices. Additionally, preregistration may help reduce publication bias by making planned studies discoverable, even if findings are not written up or published. Likely due to reducing researchers' flexibility, Kaplan and Irvin (2015) reported a significant increase in

null findings being reported in studies funded by the National Heart, Blood, and Lung Institute after the institute started requiring preregistration. Similarly, Schäfer and Schwarz (2019) reported a median effect size (r) of .16 for 93 preregistered studies in psychology, in comparison to a median effect size of .36 for 900 randomly selected non-preregistered psychology studies.

Among the primary concerns related to preregistration are potentially stifling researcher creativity and dealing with unavoidable changes in a study (Nosek et al., 2018). Preregistration is sometimes perceived as limiting researchers to conducting only preregistered analyses, disallowing exploration of unforeseen and potentially important findings. However, preregistration does not entail that researchers cannot conduct additional, non-preregistered analyses; it just distinguishes these analyses as exploratory. Researchers can and should conduct exploratory analyses, preregistration just promotes accountability for clearly reporting them as such. Additionally, unexpected changes to studies are commonplace. For example, a researcher may find that one outcome measure demonstrated low reliability with study participants, and therefore decides not to include it in the analysis (as was planned in the preregistration). In cases such as this, researchers can post an updated version of the preregistration. As soon as the researcher recognizes that study plans have changed (i.e., before analyses are conducted), an updated version of the preregistration can be posted describing and justifying the change in study plans.

State of the practice and examples in EBD research. Preregistration is becoming increasingly common, with more than 18,000 preregistered studies on the Open Science Framework alone (Kupferschmidt, 2018). Although not yet the norm for EBD researchers, multiple studies related to EBD have been preregistered. For example, Blader and colleagues preregistered their study examining the effects of an intervention involving stimulant medication

and family-based behavioral treatment on the aggressive behaviors of children with disruptive mood dysregulation disorder at ClinicalTrials.gov (a registry for intervention studies; see <https://www.clinicaltrials.gov/ct2/show/NCT00794625>).

Preregistrations were designed primarily for group-research designs and are less commonly used for qualitative and SCD studies. As SCDs (a) are used to identify evidence-based practices for students with EBD (Kratochwill et al., 2012) and (b) appear to be subject to researcher bias (Shadish et al., 2016; Sham & Smith, 2014), preregistration may be relevant for SCD researchers as well. Some SCD researchers are beginning to preregister their studies, such as the preregistration by Sadler for an SCD study exploring the use of video self-modeling to reduce challenging behaviors in students with ASD (see <https://www.sreereg.org/framework/pdf/index.php?id=1725>).

Registered Reports

What are Registered Reports? Registered Reports take the concept of preregistration and apply it as the basis for peer review. Registered Reports base the primary decision to publish on the importance of the research questions and the soundness of the proposed methods *before* a study is conducted (Hardwicke & Ioannidis, 2018). There are two stages of review in Registered Reports. In Stage 1, which occurs before data is collected, researchers submit an Introduction, stating and justifying research questions, and a detailed proposed Method section. Review is considered “results blind” because study results are unknown. If the editor grants in-principle acceptance after Stage 1 review, the researchers then conduct, write up, and submit the study for Stage 2 review. At this stage, reviewers only consider whether the researchers executed the study as planned (and, if not, any deviations are clearly identified and justified), and whether the authors report and discuss study findings fully and appropriately. See Figure 1 for a graphical

representation of the Registered Reports process. The Open Science Framework provides resources for Registered Reports at <https://cos.io/rr/>.

(Place Figure 1 here)

Benefits and concerns. Registered Reports convey multiple benefits, including reviewers providing constructive feedback for improving research before it is conducted, and removing many of the incentives for questionable research practices such as HARKing, p-hacking, selective reporting, and publication bias (Chambers, Feredoes, Muthukumaraswamy, & Etchells 2014; Hardwicke & Ioannidis, 2018). Because in-principle acceptance is based on a results-blind review, the incentive to HARK, p-hack, and selectively report findings in order to get a study published is removed. Indeed, not adhering to the proposed study hypotheses and methods is one of the only ways for Registered Reports with in-principle acceptance not to be published. Consequently, Allen and Mehler (2019) reported that null results were reported in 61% of extant Registered Reports, compared to in only 5–20% of traditional publications.

Obstacles to implementing Registered Reports include the extra time and effort involved for reviewers (who must conduct two rounds of reviews) and authors (who must write an Introduction and proposed Method before conducting the study), the potential to discourage explorative research, and the scarcity of journals that accept Registered Reports (Chambers et al., 2014). Extra time and effort are indeed required; however, that investment may be justified by the review process prospectively enhancing the quality of studies. As with preregistration, Registered Reports does not disallow or discourage exploratory research, it just requires that researchers clearly identify analyses not stipulated in accepted study plans as exploratory and justify their importance. Finally, although we are not aware of EBD-specific journals that accept Registered Reports, we imagine more journals will adopt Registered Reports in the future.

State of the practice and examples in EBD research. Registered Reports are a recent development, but are growing in popularity. As of February 2018, Hardwicke and Ioannidis (2018) reported that 91 journals were accepting Registered Reports and a Zotero library (n.d.) maintained by the Open Science Framework listed 169 published Registered Reports as of May 2019, mostly in psychology. No EBD-specific journals currently accept Registered Reports. However, *AERA Open* (n.d.) is devoting a special issue to Registered Reports, and journals in related fields such as *Behavioral Neuroscience* regularly accept Registered Reports. We identified one published Registered Report in education (Van der Zee, Admiraal, Paas, Saab, & Giesbers, 2017), which did not find the hypothesized effects of subtitles on learning outcomes in Massive Open Online Courses.

Open Data and Materials

What are open data and materials? Open data (sometimes called data sharing) refers to publishing the actual data for a study in a public repository so that others can re-analyze the data, include the data in research syntheses, and explore new questions and analyses (O. Klein et al., 2018). Data sets then become a product from a research study that others can use and cite. To share data, researchers submit raw data (some of which may be redacted, as appropriate) for a specific study. To make data usable by others, researchers also provide a codebook or data dictionary (i.e., a guide to the names of the data fields or columns). Shared data should accord with the FAIR principles: Findable, Accessible, Interoperable (easily integrated with other data), and Reusable (Wilkinson et al., 2016). O. Klein et al. (2018) recommended posting data on a publicly accessible repository that assigns persistent and unique identifiers to products, accommodates meta-data, tracks data re-use, accommodates licensing (allowing researchers to restrict data re-use), features access control (allowing researchers to limit access), guarantees

long-term access, and accords with local regulations. Open materials refers to publicly posting other materials needed to replicate a study, such as analytic code, detailed researcher protocols, and survey items. Researchers can choose from many repositories for posting data and materials, including those at <https://osf.io>, <https://www.icpsr.umich.edu/icpsrweb/>, and <https://figshare.com>. See Levenstein and Lyle (2018) for general guidelines on data sharing and Soderberg (2018) for sharing data on the Open Science Framework specifically.

Benefits and concerns. Open data and materials correspond with Merton's (1973) norm of universalism in science and enable others to examine the credibility of research findings by (a) replicating the original analyses (i.e., analytic reproducibility), and (b) conducting different analyses with the same data to test the analytic robustness of study findings (O. Klein et al., 2018). Additionally, sharing data allows other researchers to integrate multiple data sets (e.g., in research syntheses) and to explore new research questions. O. Klein et al. (2018) also noted that open data protects against losing data.

Despite these benefits, most researchers do not publicly share their data because of barriers such as the time necessary to prepare and post data sets, concerns about protecting the anonymity of participants, and fears of others using shared data before the researcher is finished analyzing and publishing from the data set (i.e., being scooped; Houtkoop et al., 2018). Time required to prepare a data set and codebook for others to use is a genuine concern. However, given the benefits of open data, this cost may be justified. Although the risk of identification of research participants cannot be eliminated, it can be minimized by not using direct identifiers (e.g., names, initials) and minimizing reporting of indirect identifiers (e.g., school, grade level; O. Klein et al., 2018, supplementary materials). See Walsh et al. (2018) and Meyer (2018) for discussions of de-identifying shared data and ethical data sharing, respectively. To guard against

being scooped, researchers can temporarily embargo (i.e., delay) access or restrict access to certain individuals. Moreover, researchers do not need to provide access to all of the data from a multi-study project, but only the data relevant to the published study.

State of the practice and examples in EBD research. Open data is not the norm for researchers in EBD. However, some researchers in EBD and related areas have chosen to share their data publicly. For example, Vernon-Feagans, Crouter, and Cox (2018) posted their data from the Family Life Project, which investigated the relation between risk factors in early childhood and subsequent child outcomes such as behavioral competence, on the ISCPDR repository. Vernon-Feagans et al. (2018) shared some data files publicly, whereas other data files were restricted to those who were granted access. Nook, Sasse, Lambert, McLaughlin, and Somerville (2018) shared both data (a link to the data on the Open Science Framework is provided) and materials (e.g., power simulations, tables of supplemental statistical analyses, a detailed scoring guide for a vocabulary assessment) with their study of differences in emotional differentiation in children adolescents and young adults. Additionally, outcome data in SCDs, a common research design used in EBD and related fields, is in essence shared because each data point is graphed and can typically be extracted reliably. So, much of the data in the EBD research base is open by default. Nonetheless, SCD researchers are encouraged to share their data on a public repository (Pustejovsky & Ferron, 2017) to ensure accuracy and increase efficiency of conducting research syntheses, as well as provide access to data on treatment fidelity, social validity, and reliability of the outcome measure.

Open Access and Preprints

What are open access and preprints? Published research is typically kept behind a paywall; if not affiliated with an institution that subscribes to the publisher's service, one must

pay to access published research. Open access refers to providing free access to research and other scholarly work on the internet (Tennant et al., 2016). A few journals are entirely open access; research consumers can freely access all articles on the websites of open-access journals. Most publishers of traditional journals now also provide an option to authors to make individual articles open access. To publish a paper in an open-access journal or to make an article open access in a traditional journal, authors typically pay a fee set by the journal.

Preprints (sometimes simply called papers) provide another option for making research openly accessible. To post a preprint, a researcher uploads a non-copyrighted version of their paper (e.g., a .pdf version of their double-spaced manuscript) to a publicly accessible preprint server. Preprint servers can be general (e.g., <https://www.preprints.org/>, <https://osf.io/preprints>; although not exclusively a preprint archive, researchers across disciplines can post preprints on <https://www.researchgate.net>) or domain specific (e.g., <https://www.biorxiv.org>, <https://psyarxiv.com>). As the name implies, preprints are typically posted before a paper is published in a journal. However, preprints may never be published in a journal, or can be posted after a paper is published (depending on journal policies). Preprint servers do not typically involve a cost. Preprints are not peer reviewed in a traditional sense, but some preprint servers provide a forum for ongoing review by enabling readers to post comments (i.e., reviews) on posted manuscripts. The Open Science Framework provides guidelines and answers to frequently asked questions about preprints at <http://help.osf.io/m/preprints>.

Benefits and concerns. The primary benefit of open access is making research findings available to all stakeholders with internet access. Research will not have its desired effect on practice and policy if it is behind a paywall where only some stakeholders can access it. Additionally, by obviating the peer review process, preprints (a) accelerate the availability of

research findings and (b) may encourage dissemination of (and make discoverable for inclusion in research syntheses) research that may be unlikely to be published in a journal (e.g., studies with null findings; Bourne, Polka, Vale, & Kiley, 2017). Preprints can also provide a forum for ongoing review and feedback that is not available in traditional journal publications.

A primary caveat of open-access publishing is cost. For example, the standard cost to make an article open access in EBD journals published by Sage is currently \$3,000; the cost to publish a paper in the open-access journal *PLOS* is \$1,595. A primary caveat related to preprints is that they have not been vetted through peer review. Accordingly, readers should take a cautious and critical approach when reading preprints. Additionally, although most journals accept submissions that have been posted as a preprint, some may not (COPE Council, 2018; see journal websites and <http://sherpa.ac.uk> for journals' policies). Finally, some researchers may be reluctant to post their work as a preprint prior to publication for fear of someone else scooping them and publishing their idea. However, preprints are time stamped upon being uploaded, and thereby establish priority of discovery (Berg et al., 2016).

State of the practice and examples in EBD research. Although researchers in EBD and related fields sometimes publish in open access formats and post preprints, the norm is still to disseminate research in traditional journal publications. Although there are no open-access journals specific to EBD, researchers have published EBD-related research in education open-access journals such as *AERA Open* (e.g., Lewis, McIntosh, Simonsen, Mitchell, & Hatton, 2017), general open-access journals such as *PLOS* (e.g., Siew, Mazzucchelli, Rooney, & Girdler, 2017), and open-access journals in other fields such as *British Medical Journal Open* (Santosh, Tarver, Gibbons, Vitoratou, & Simonoff, 2016). Additionally, researchers have made their work published in traditional EBD journals such as *Journal of Emotional and Behavioral Disorders*

open access (e.g., van den Berg & Stoltz, 2018). EBD researchers have also posted preprints on various preprint servers. For example, Braverman, Dunn, and Vishedskiy (2018) posted their research on the development of a parent-report evaluation instrument for children with autism on Preprints (<https://www.preprints.org/manuscript/201804.0216/v1>) before it was published in the journal *Children*.

Open Peer Review

What is open peer review? Open peer review aims to make the peer review process more transparent, accountable, and meaningful. Open peer review encompasses multiple and disparate reforms (Ross-Hellauer, 2017), of which we discuss three: (a) open identities (or signed reports), (b) open reports (or transparent review), and (c) open commenting (or post-publication review). Open identities involves not masking the identities of authors or reviewers, such that authors and reviewers are aware of each other's identities. Single-blind review, in which author but not reviewer identity is masked, is one variant of open identities. Open reports is when reviews are published alongside articles (e.g., on the journal website). Published reviews can be anonymous or include the reviewers' identities. Open commenting enables ongoing review of articles after publication. Open commenting can occur alongside an electronic version of a manuscript (e.g., on a journal's website, on a preprint archive), or separate from the manuscript (e.g., on *Twitter* and blogs; Ross-Hellauer, 2017).

Benefits and concerns. Although scholars generally support the benefits of traditional peer review (Ware, 2016), it has also been critiqued as unreliable, resource intensive, time consuming, lacking accountability, biased, limited (e.g., involving only three reviewers), and wasteful (only authors and editors see reviews; see Ross-Hellauer, 2017). Reviewers may be less caustic, dismissive, or perfunctory if their identity is provided with the review, though research

suggests effects of open identity on review quality are small (Bruce, Chauvin, Trinquart, Ravaud, & Boutron, 2017). Open reports enhance accountability and recognition of reviewers by making reviews, and potentially reviewer identity, publicly available. Open reports also reduces waste, in that all readers, not just study authors, can access reviewers' comments. Open commenting enlarges the scope of review and enables a dialogue between researchers and research consumers. Multiple concerns exist related to open-review reforms, including the lack of evidence supporting their efficacy, researchers' general lack of enthusiasm for their use (e.g., Ware, 2016), and the possibility that unmasking reviewer and author identity may lead to biased reviews and reprisals for negative reviews.

State of the practice and examples in EBD research. We are not aware of EBD journals using open review practices. Double-blind peer review is, in our experience, standard practice. However, some general open-access journals that use open review have published papers related to EBD. For example, Capobianco and Cerniglia's (2018) case study of a girl with selective mutism was published in the open-access journal *F1000Research*, which uses open review. The online version of the article (<https://f1000research.com/articles/7-221/v1>) provides links to the three reviews and the identities of the reviewers are provided. Additionally, the number of views, suggested citation format, competing interests of reviewer, and reviewer expertise is provided for each review. Readers can provide ongoing comments on the article, though none have been made to date. In the open-access journal *PeerJ* reviewers are encouraged, but not required, to share their identities, and authors are provided the option of publishing the entire review process with the final article. For example, Arias, Esnaola, and Rodriguez-Medina (2018) published the review process (including editorial decision letters, reviews from two reviewers who chose to remain anonymous, and the originally submitted manuscript) with their

study examining the discriminative capacity of ADHD symptoms (see <https://peerj.com/articles/4820/reviews/>).

Improving EBD Research and Practice

We believe that implementing open science practices in EBD research has the potential to improve research and practice in the EBD field. For open science to become the norm for researchers in the EBD field, a change in the culture of research needs to occur.

Providing Trustworthy Evidence for Practice

Open science is not just an academic issue, but has implications for practice. Scholars have suggested that research is the most reliable approach for discerning the effectiveness of practices, and should therefore inform instructional decision making for students with EBD (Zaheer et al., 2019). However, a gap between research and practice exists in special education broadly (Cook & Farley, in press) and in the EBD field in particular (Gable et al., 2012). Carnine (1997) proposed that research findings must be trustworthy, useable, and accessible for practitioners to implement them. Open science directly addresses two of Carnine's recommendations: trustworthiness and accessibility. Preregistration, Registered Reports, and open data are designed to improve the trustworthiness of research by reducing bias and facilitating verification. Furthermore, data and materials sharing, as well as preprints, help accelerate the accessibility of science, enabling researchers to address practical issues more quickly. Thus, by improving critical aspects of research, open science has the potential to provide a more trustworthy and accessible basis for practice and policy for students with EBD.

Advancing the Culture of Research for EBD

As the aforementioned examples illustrate, open science is gaining footholds in special education and the EBD field. Despite these initial advances, "there's still a long road ahead for it

[open science] to become commonplace” (International Center for Scientific Debate, 2018, p. 2).

To be expanded and sustained, open science will need to be incentivized further. Although engaging in open practices has not been recognized in tenure, promotion, and hiring decisions traditionally, standards may be shifting to acknowledge this work (Schönbrodt, 2018).

Additionally, initial evidence suggests that engaging in open practices is associated with traditional academic incentives such as citations (McKiernan et al., 2016). For example, research has shown that open access articles are cited more often than publications behind paywalls (e.g., Piwowar et al., 2018) and receive greater media coverage (Wang, Liu, Mao, & Fang, 2015). Similarly, Serghiou and Ioannidis (2018) found that articles with associated preprints were cited significantly more often than articles without; and Piwowar and Vision (2013) documented a citation advantage for studies with shared data. Recognition that open science practices are associated with institutional and scholarly incentives may further promote their acceptance and application.

Journals in special education are beginning to incentivize researcher implementation of open science principles. *Exceptional Children* now awards badges for authors who (a) preregister the study, (b) provide open access to data, and (c) make study materials free and publically available. Authors can earn one, two, or all three of these badges, with the badges earned displayed prominently on the page of the published article. Although implementation of badges in special education is new, fields that have implemented badge for a sustained period of time have reported a significant increase in authors implementation of open science practices. For example, once badges were implemented in *Psychological Science* the number of articles with open data increased from 3% to 39% (Giofrè, Cumming, Fresc, Boedker, & Tressoldi, 2017).

Conclusion

Implementation of effective instructional practice is paramount for providing a truly special education and improving the educational outcomes of students with EBD. Although scientific research is generally regarded as the most valid basis for determining effective instruction, contemporary research culture is not wholly constructed for incentivizing sound, trustworthy research; publishing studies with null findings to refute the efficacy of ineffective practices; or making research findings accessible to all stakeholders. Though not a panacea, implementation of open science practices, such as preregistration, Registered Reports, open data and materials, open access and preprints, and open review, may help move the EBD field toward a more trustworthy and accessible research base; which, in turn, facilitates effective, evidence-based instruction for some of our most vulnerable children and youth—students with EBD.

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Figure 1. The process of Registered Reports